# Latent variable models for time-to-event data (continuous time)

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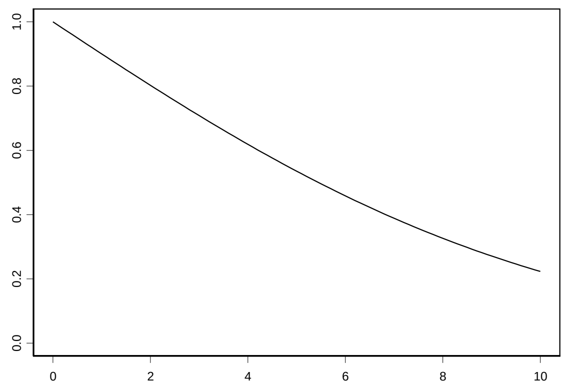
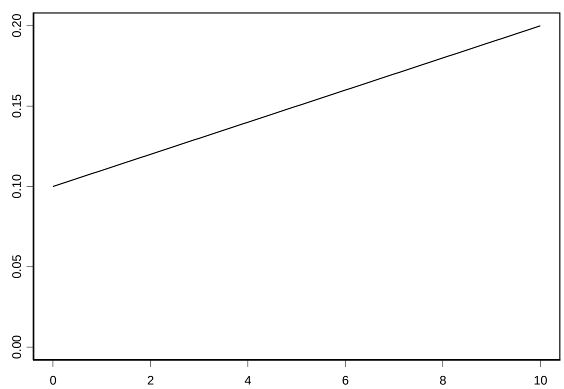
# Cox's model (Cox, 1972)

$T$: time to event, e.g. time from onset of a disease to death

$S(t)$: probability of surviving to time $t$




$\lambda(t)$: intensity




$\lambda(t)$ is the continuous time counterpart to $h(t)$

Cox: proportional intensities

## Combining the Growth Mixture Model and Cox's model

Include variables from the Growth Mixture Model as predictors in the intensity function, e.g.

1. latent continuous variables

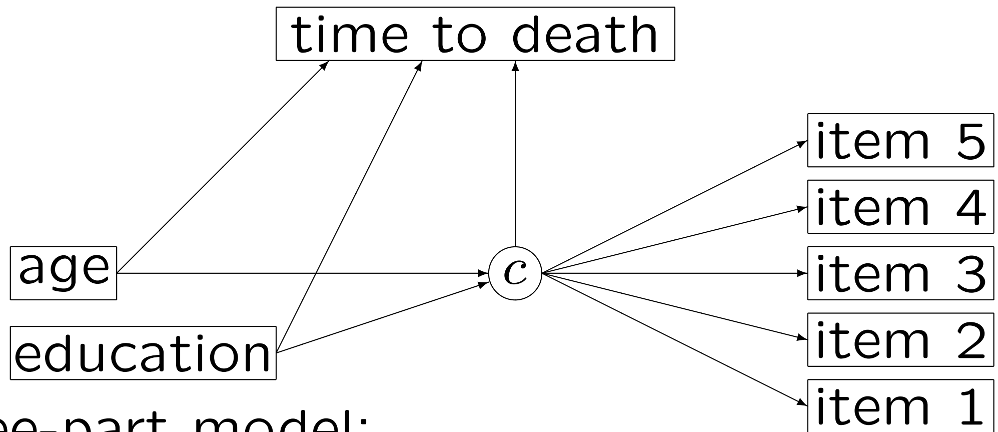
2. latent class variables

## Two examples

1. CD4 counts predicting death for people with AIDS (e.g. Tsiatis *et al*, JASA, 1995; Wulfsohn and Tsiatis, Biometrics, 1997)

2. longitudinal measurements of prostate specific antigen define latent classes that predict onset of prostate cancer (Lin *et al*, 2002*a,b* - **DRAFTS**)

# Women's Health and Aging Study, Johns Hopkins, NIA




Three-part model:

1. measuring the latent class c

2. distribution of c given covariates

3. distribution of time-to-event given covariates and latent class

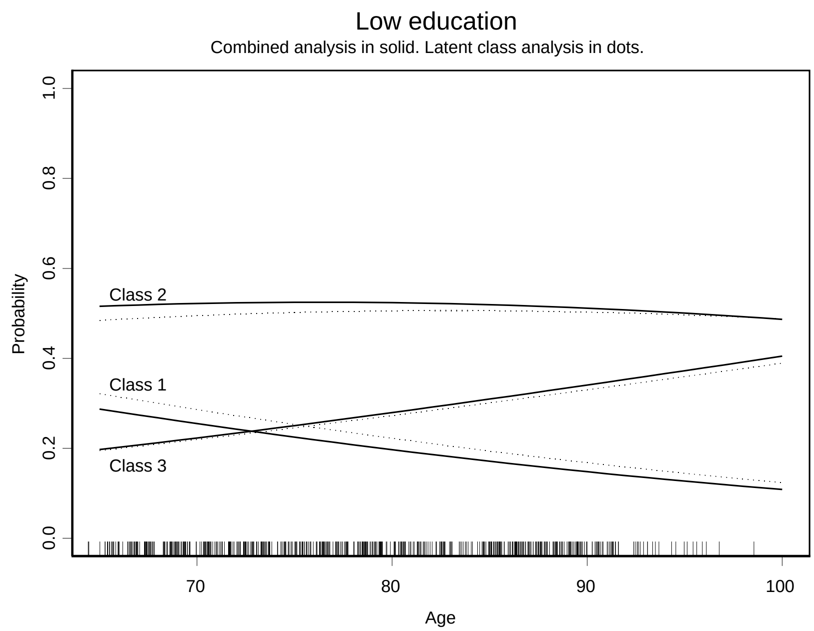
Klaus Larsen (2002). Survival analysis with multiple discrete indicators of latent classes. **DRAFT**

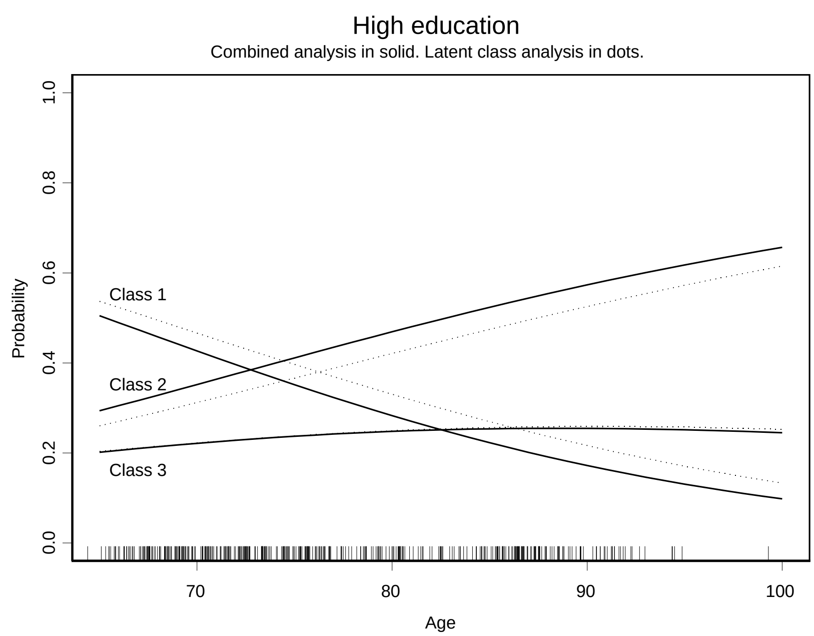
## Main result: latent class analysis part

- five items measuring mobility

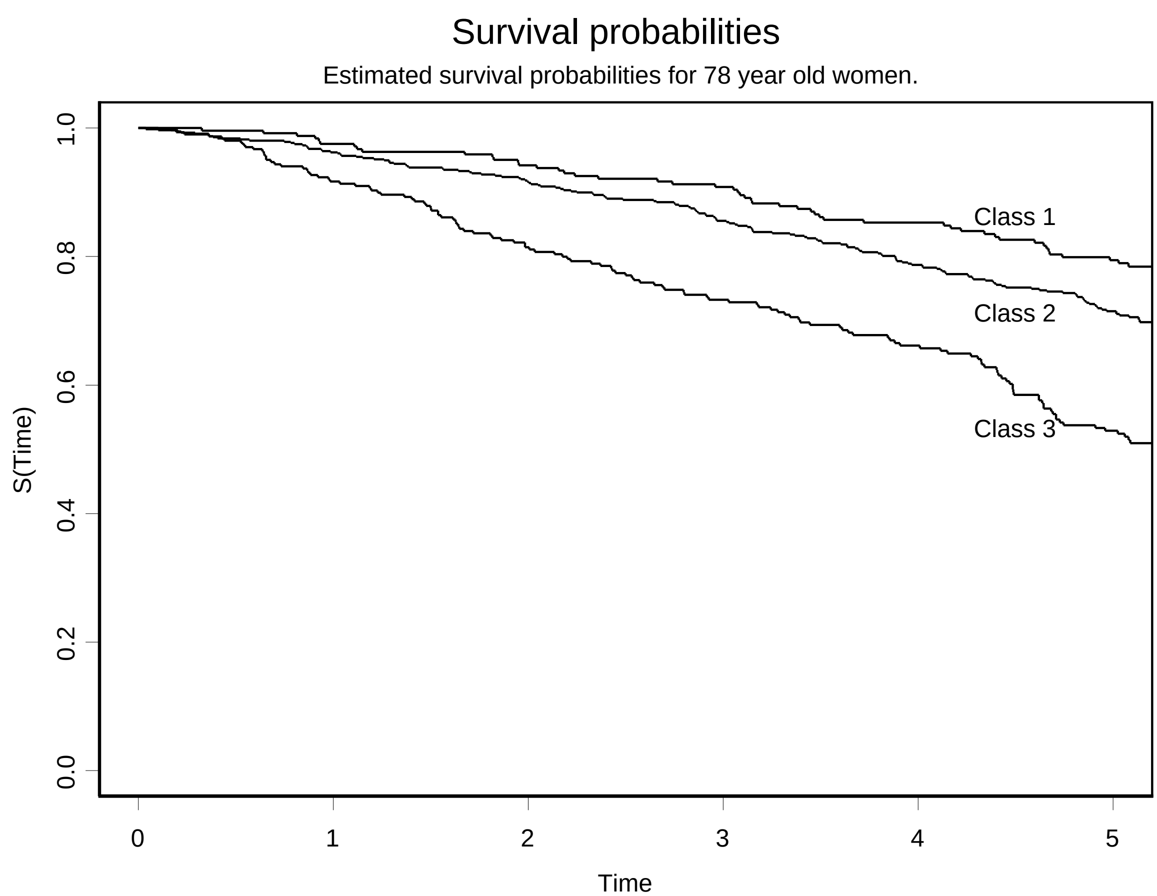
- three latent classes (Bandeen-Roche *et al.*, 1997)
  - class 1 = good mobility
  - class 2 = moderate mobility
  - class 3 = poor mobility

# Main result: latent class analysis part (cont.)



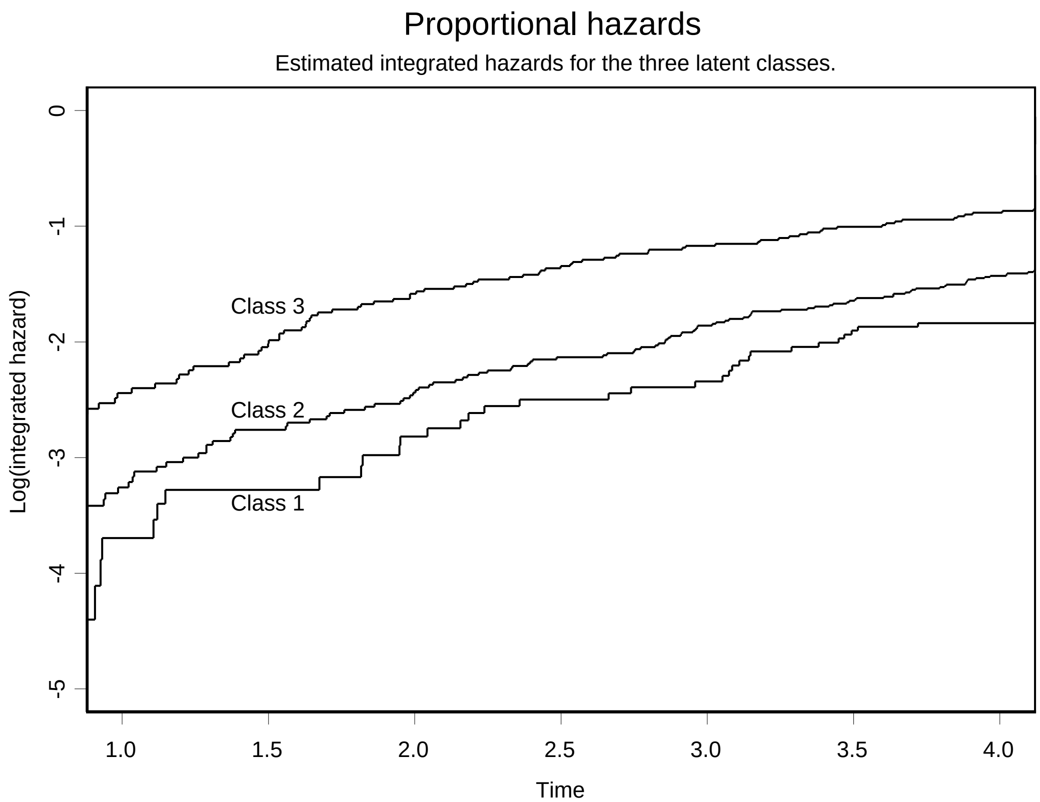



# Main result: time-to-event part




Five years survival for women aged 78 years

# Main result: time-to-event part (cont.)



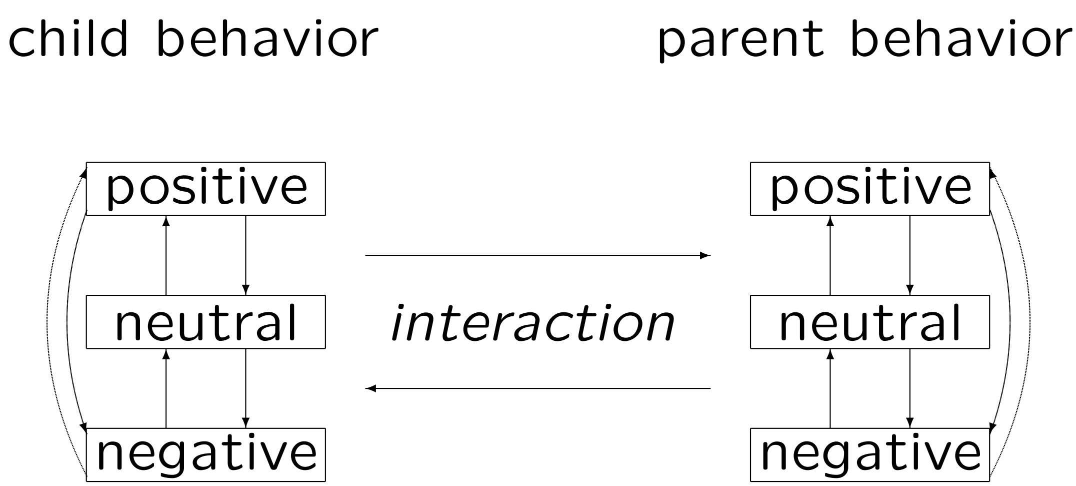

- proportional hazards assumption seems fine (curves should be parallel)

- excessive risk of approximately 195% for class 3 compared to class 1

- excessive risk of approximately 75% for class 2 compared to class 1

## Modeling social processes

Thoughts generated from the presentation by Jim Snyder at the PSMG conference call, January 30th 2002




- states measured each second

- several different behavior monitored

## Modeling social processes (cont.)

1. **A.** Regress the child's transitions between states on the child's and the parent's history.

   $h_{\mathsf{child}}(t) = \mathsf{pr}(y_{\mathsf{child}}(t)|y_{\mathsf{child}}(t{-}1), y_{\mathsf{parent}}(t{-}1))$

   **B.** Extend to two interacting processes by regressing both the child's and the parent's processes on their history.

   $h_{\mathsf{child}}(t) = \mathsf{pr}(y_{\mathsf{child}}(t)|y_{\mathsf{child}}(t{-}1), y_{\mathsf{parent}}(t{-}1))$

   $h_{\mathsf{parent}}(t) = \mathsf{pr}(y_{\mathsf{parent}}(t)|y_{\mathsf{child}}(t{-}1), y_{\mathsf{parent}}(t{-}1))$

2. Model $(y_{\mathsf{child}}(t), y_{\mathsf{parent}}(t))$ as a multi-state process.

   $h(t) =$

   $\mathsf{pr}(y_{\mathsf{child}}(t), y_{\mathsf{parent}}(t)|y_{\mathsf{child}}(t{-}1), y_{\mathsf{parent}}(t{-}1))$

## Challenging extensions of the latent variable models for time-to-event data for events in discrete or continuous time

- recurrent events (e.g.absence from work)
- multiple simultaneous processes (e.g. interactions between individuals)
- competing risks (e.g. death from different causes)
- multi-state models (e.g. women moving between states of mobility)
- growth mixture models (e.g. PSA and prostate cancer)