A hazards approach to the biometric analysis of infant mortality

Göran Broström[1] Tommy Bengtsson[2]

[2]CED, Lund University (tommy.bengtsson@ekh.lu.se)

[1]CEDAR, Umeå University (gb@ehar.se, https://github.com/goranbrostrom)

Outline

- Bourgeois-Pichat (1951): Biometric analysis of IM (background).
- Hazard-based alternative.
- Theoretical considerations
- Real-world examples.

Bourgeois-Pichat and causes of death

- Two categories:
  - Endogenous: *inherited*, *delivery*, etc.
  - Exogenous: *accidental*, *infectious diseases*, etc.
- How to differentiate between the two categories without infornation of causes of death?

Bourgeois-Pichat's Biometric model.

The biometric model

Two postulates:

1. Endogenous deaths only occur during the neonatal period (0–28 days).
2. On a specific time scale, exogenous infant mortality is uniformly distributed.

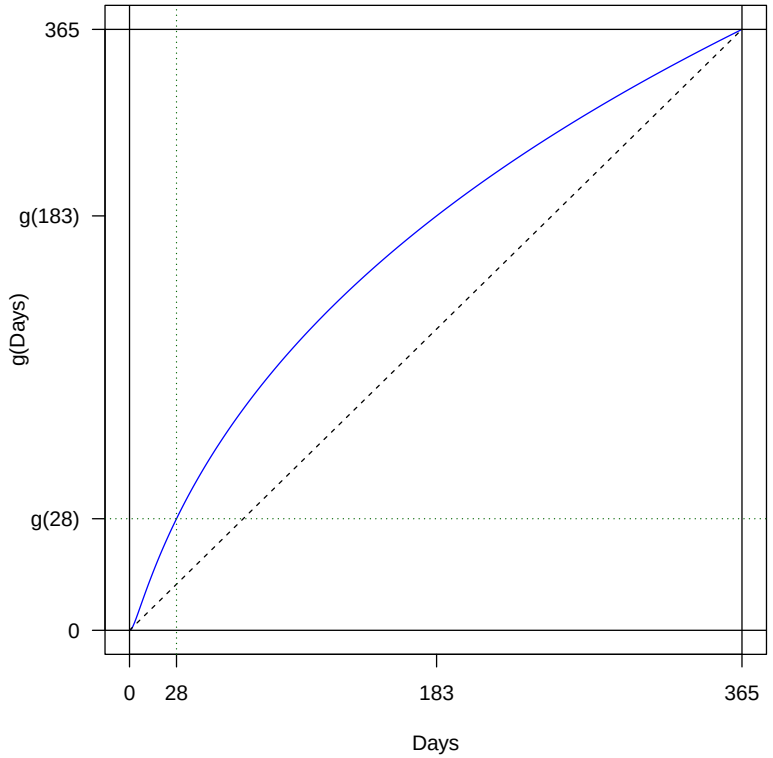
The log-cube transform

$$g(t) = C \log^3(t+1),\ 0 < t \leq 365.$$

where C is a normalizing constant:

$$C = \frac{365}{\log^3(365+1)}$$

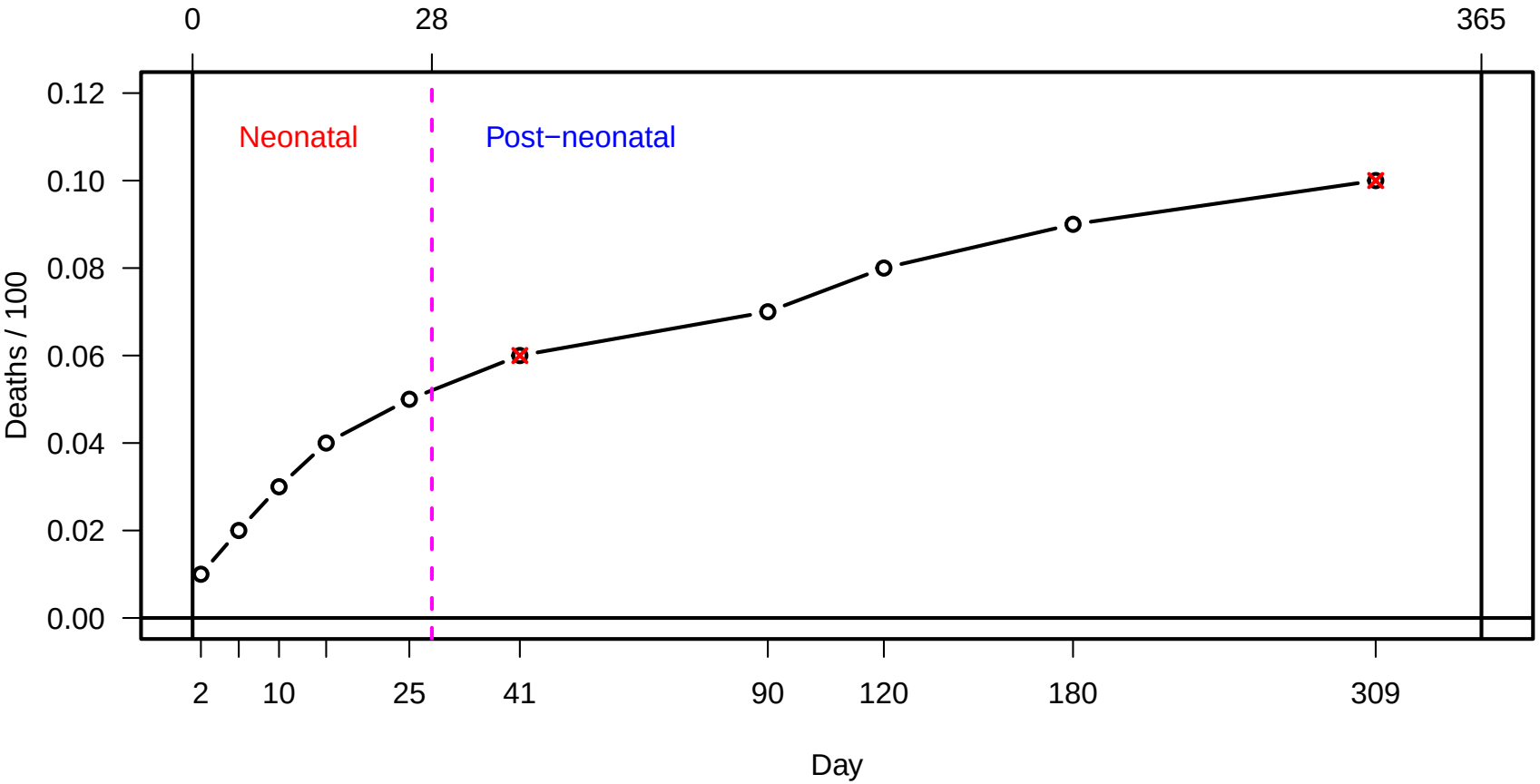
Note: C is not part of B-P's original definition.



Demonstration of the B-P plot

Assume 100 births, of which 90 survives infancy, ten death ages:

2, 6, 10, 15, 25, 41, 90, 120, 180, 309.

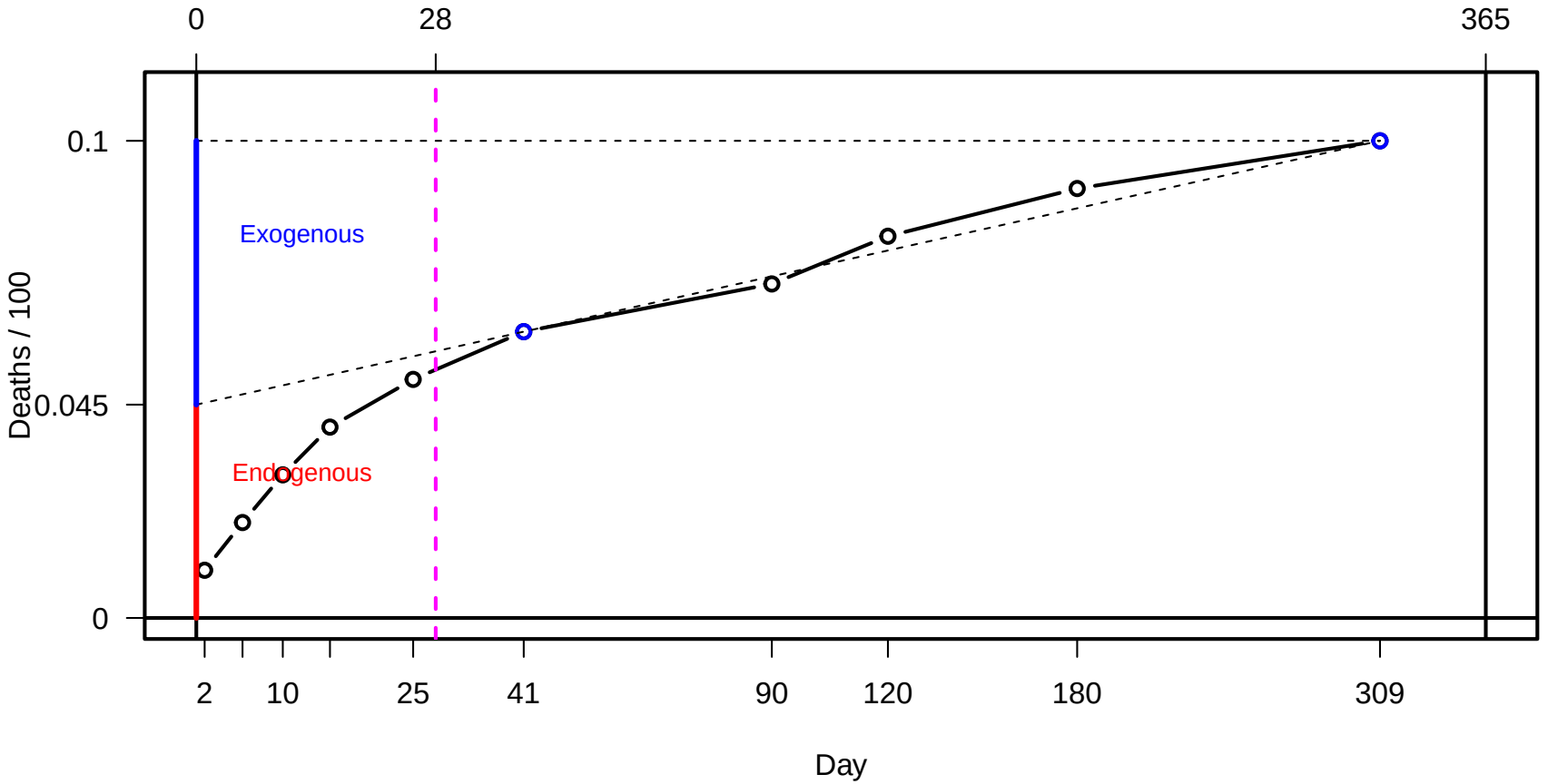


Calculation (no ties): $\frac{1}{100}, \frac{2}{100}, \frac{3}{100}, \ldots, \frac{10}{100}$.

Demonstration of the B-P plot II

Assume 100 births, of which 90 survives infancy, ten death ages:

2, 6, 10, 15, 25, 41, 90, 120, 180, 309.

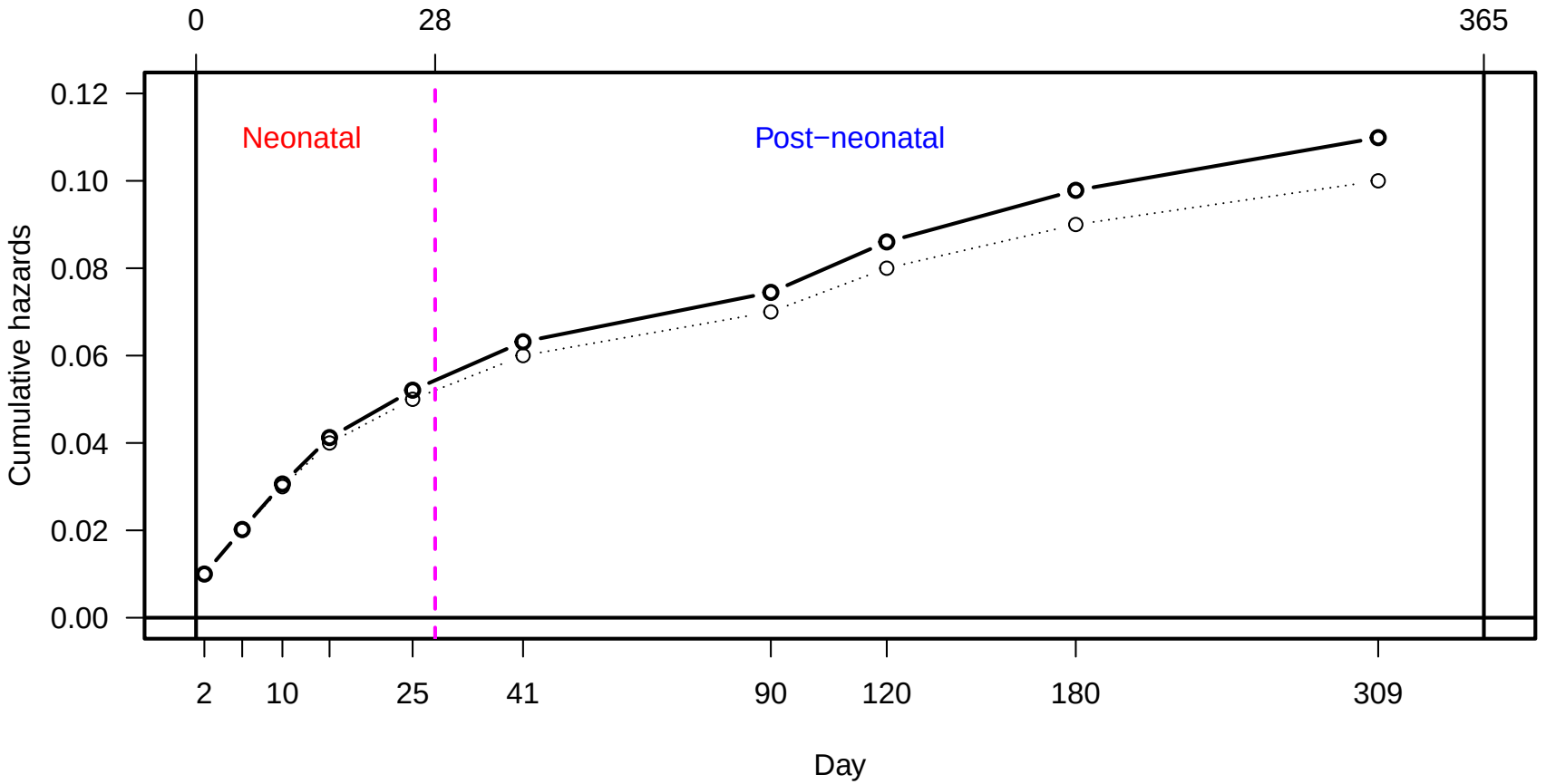


Calculation (no ties): $\frac{1}{100}, \frac{2}{100}, \frac{3}{100}, \ldots, \frac{10}{100}$.

The hazards plot

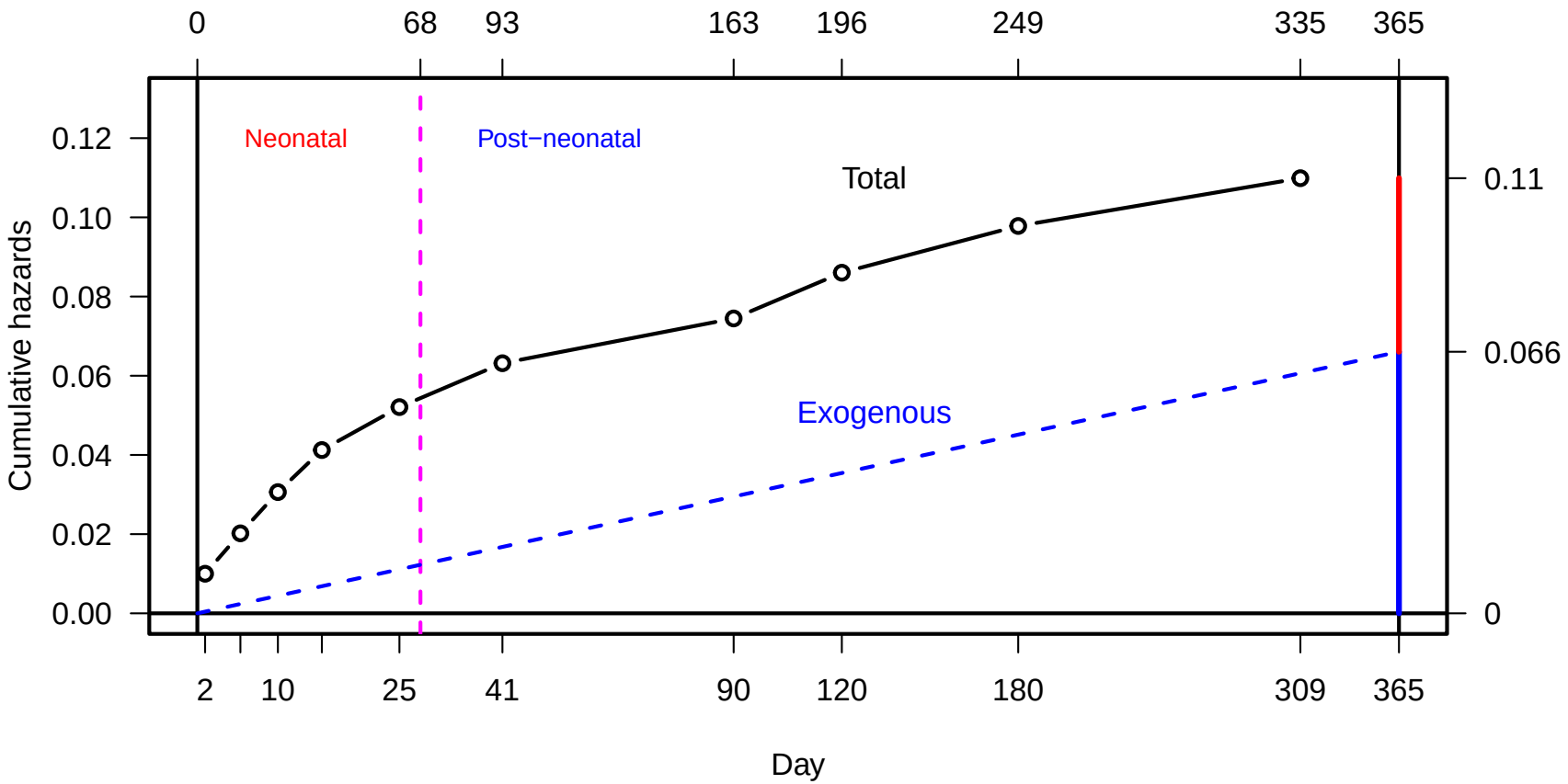
Assume 100 births, of which 90 survives infancy, ten death ages:

2, 6, 10, 15, 25, 41, 90, 120, 180, 309 (same as before).



Calculation (no ties): $\frac{1}{100}, \frac{2}{99}, \frac{3}{98}, \ldots, \frac{10}{91}$.

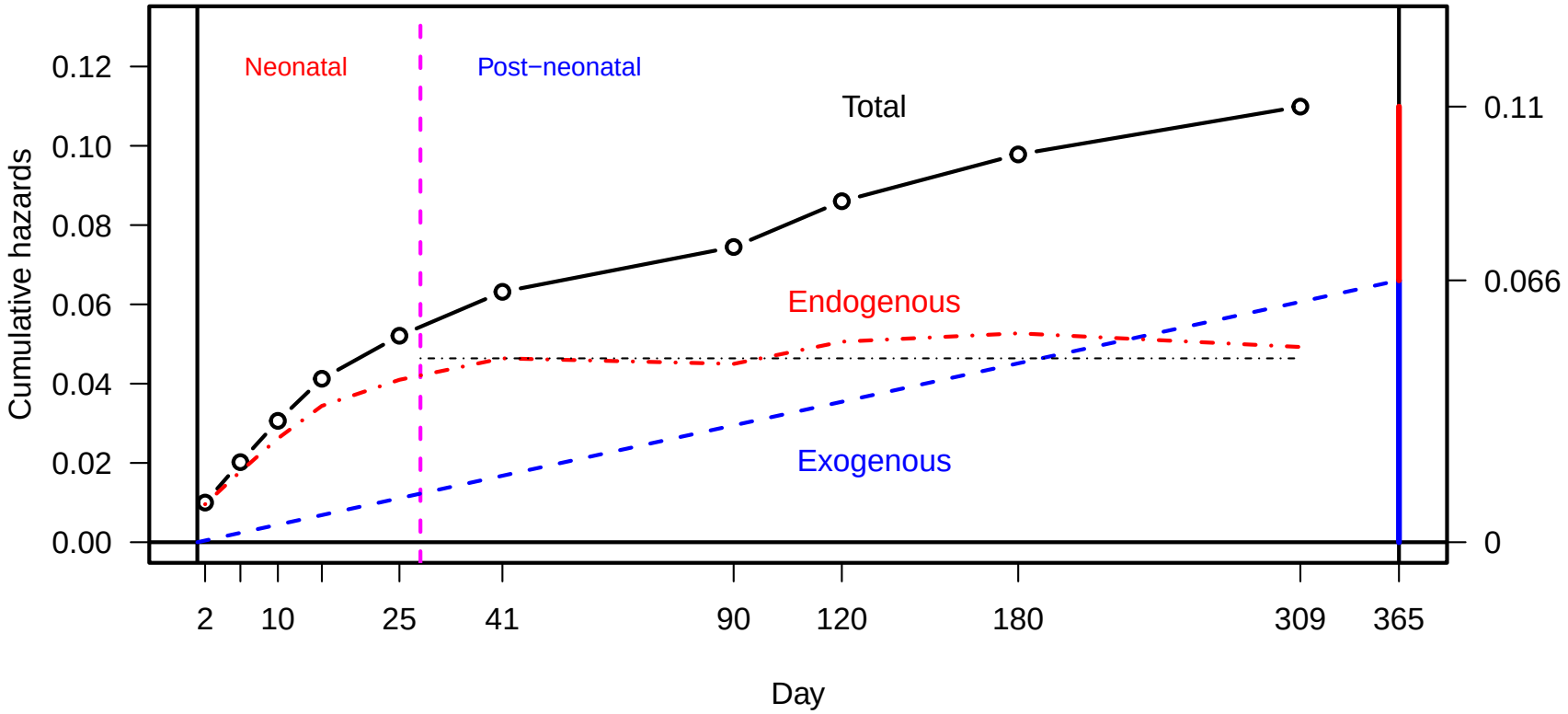
The hazards plot II



$$\text{Exogenous slope} = \frac{\#(\text{post deaths})}{\text{post exposure}} = \frac{5}{27626} \approx 0.00018$$

$$\text{Post exposure} = 90(365 - 68) + (93 - 68) + (163 - 68) + \cdots + (335 - 68) \approx 27626$$

Adding the endogenous mortality

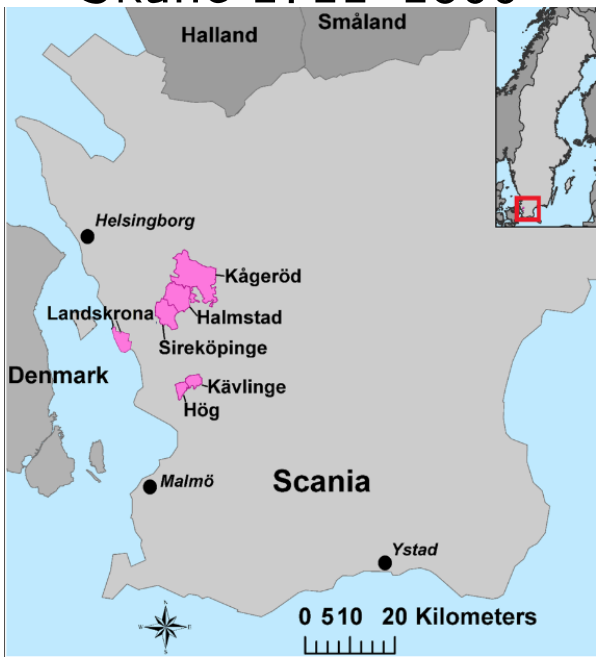


Earlier work

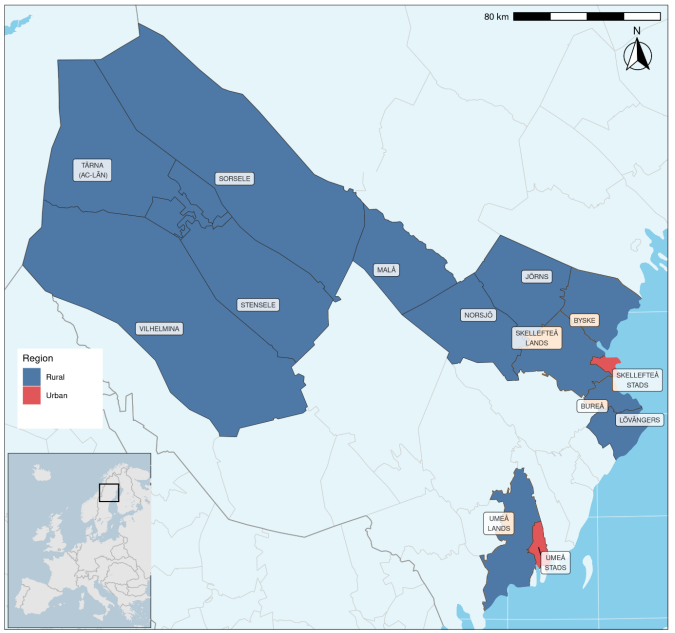
- Knodel & Kintner (1977).
  - Discusses effects of breastfeeding habits.
- Wrigley (1977).
  - Problems with data recording.
- Lynch, Greenhouse & Brändström (1998).
  - Mentions “constant hazard”.
  - Suggest linear regression methods.
- Bengtsson (1999).
  - Data quality.
- Manfredini (2004).
  - Deals with effect of climate variation.

Study areas

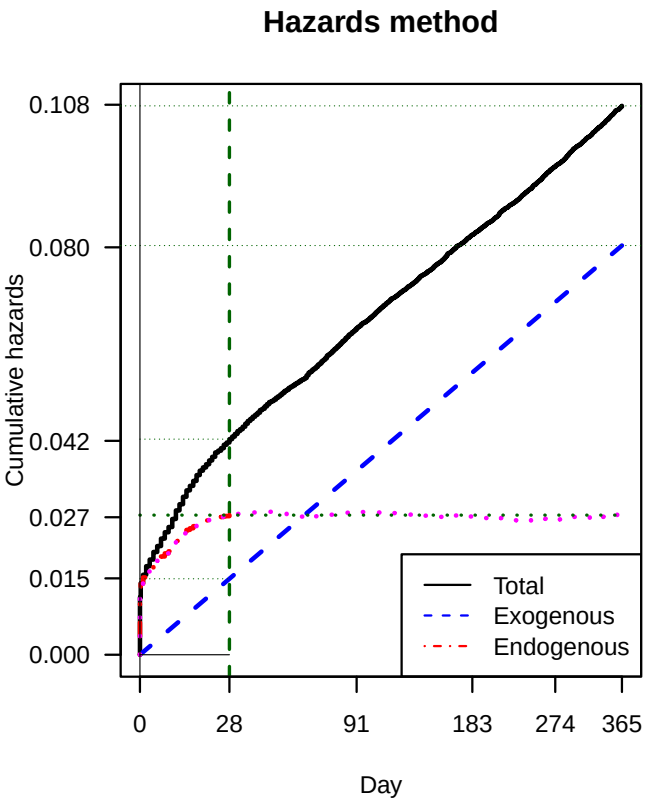
Skåne 1711–1800

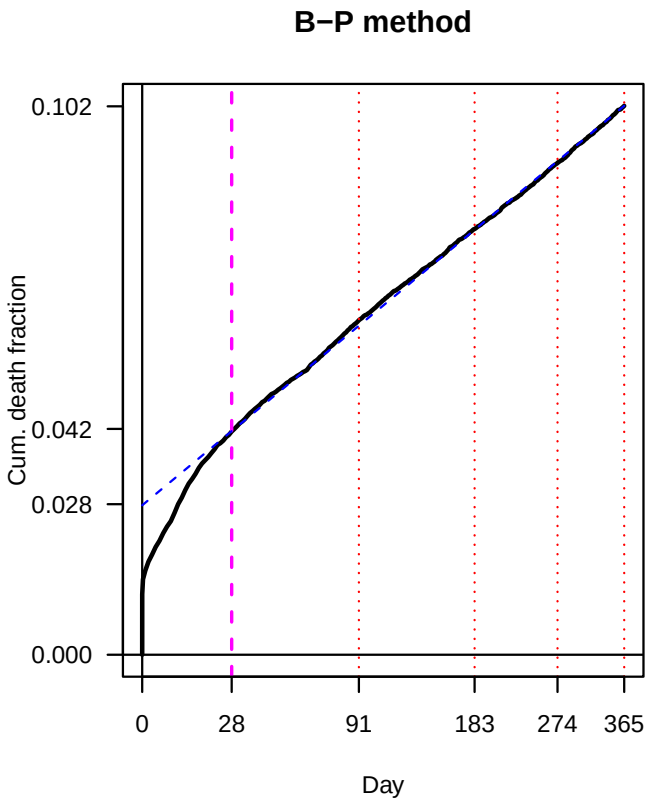


Västerbotten 1801–1950

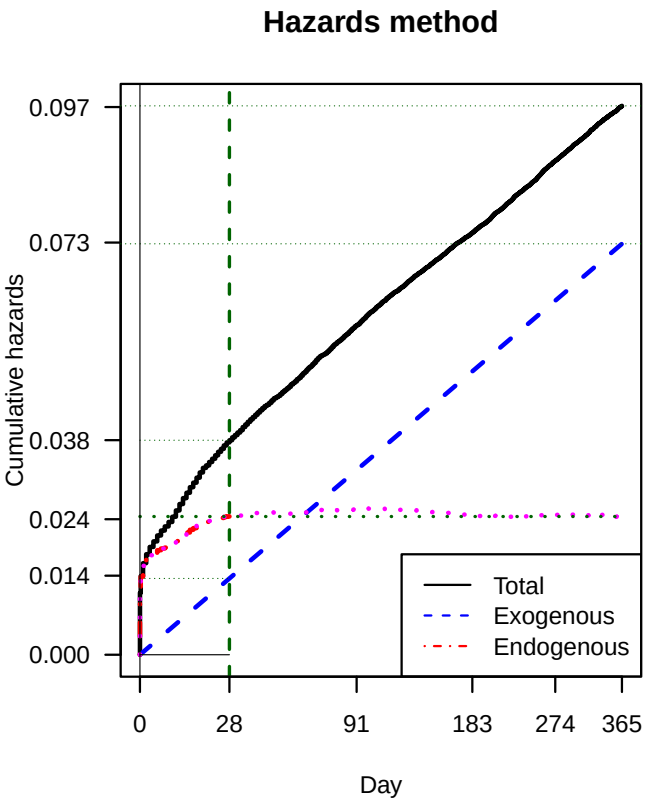


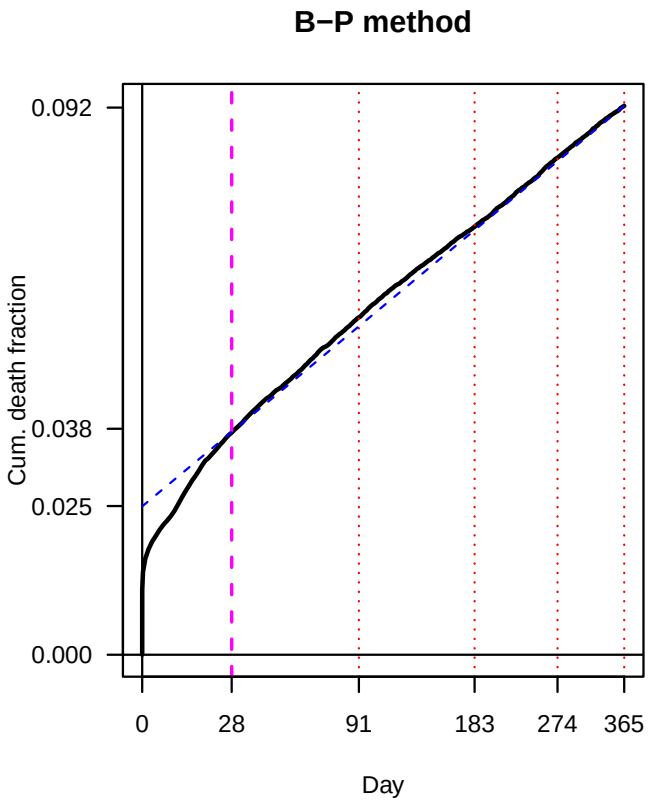
Väterbotten 1861-1890



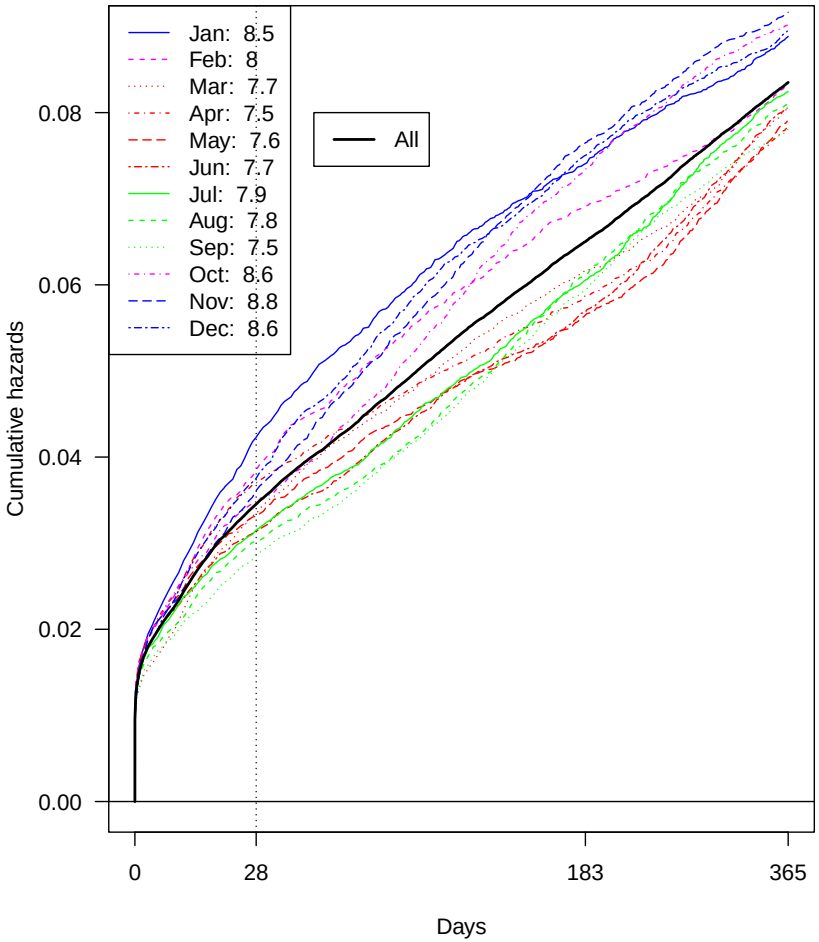


Västerbotten 1921–1950





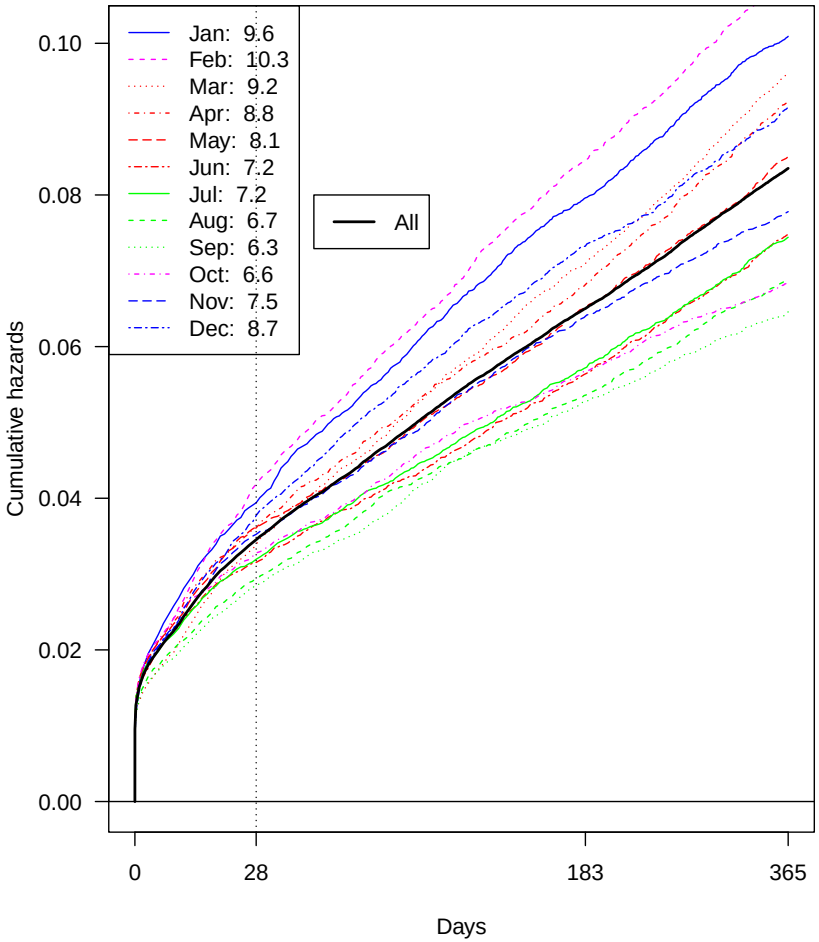
Cohort effect of birth month, Västerbotten



Conclusion:

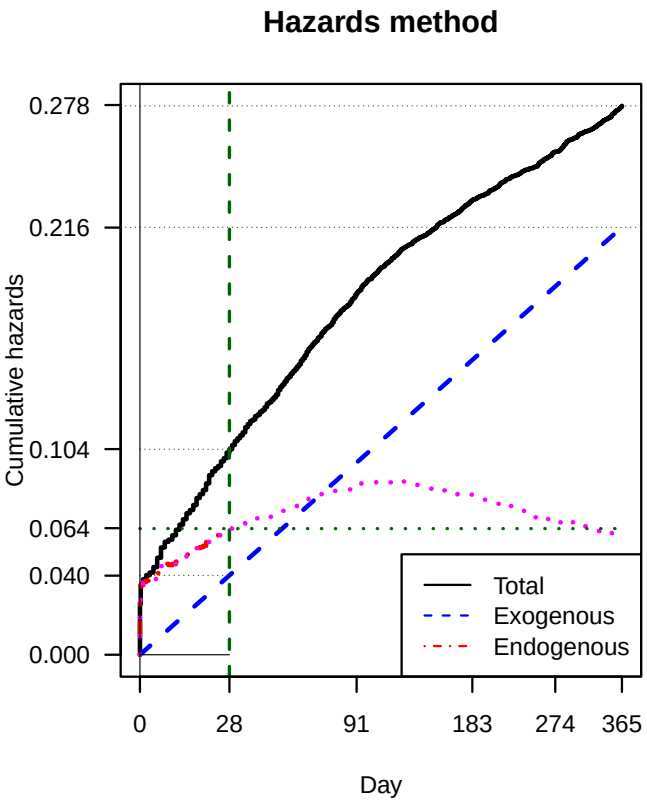
Post-neonatal linearity is a population property, not an individual.

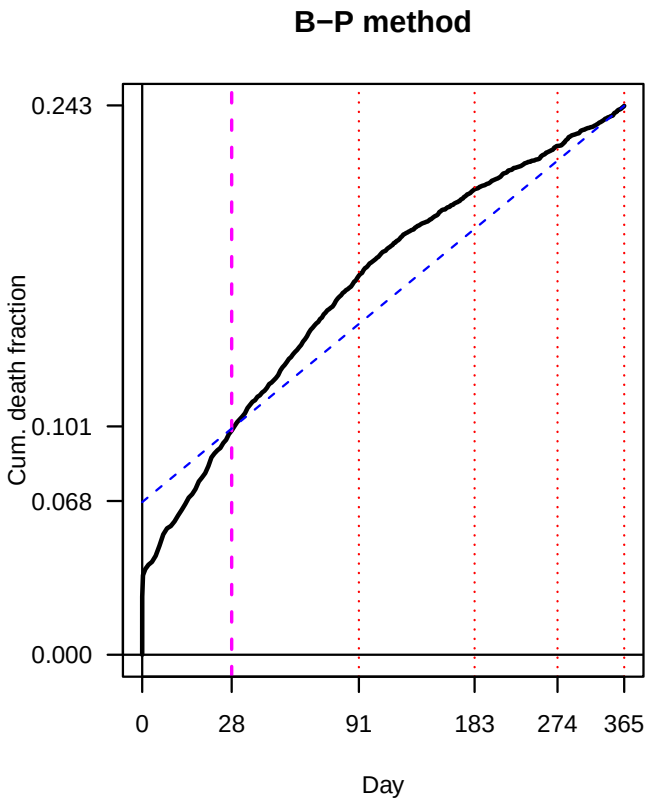
Period effect of month, Västerbotten

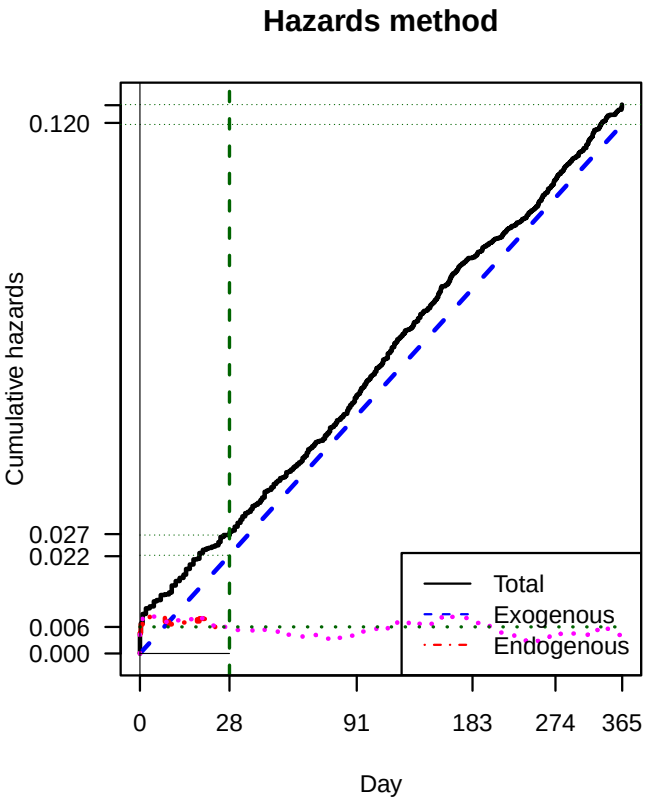


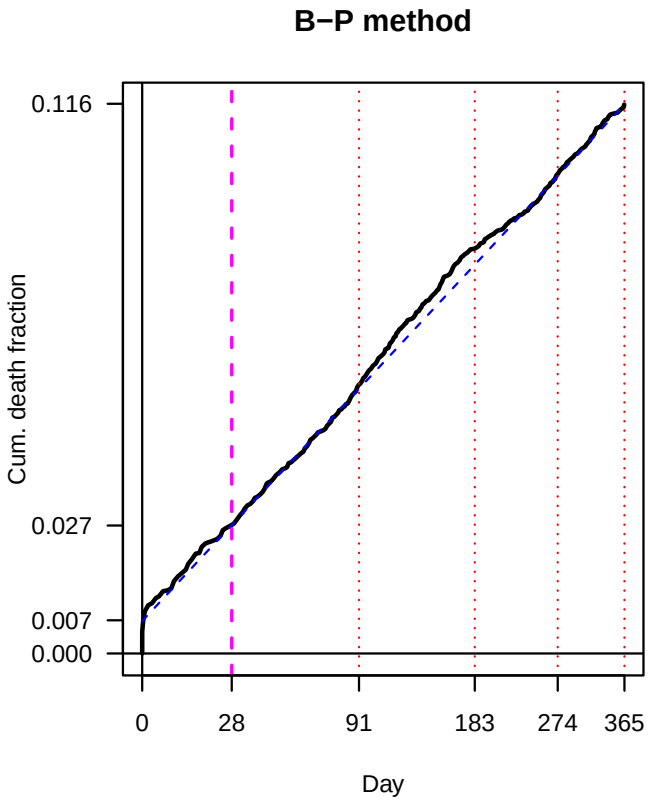
Looks quite proportional!

Scania 1711–1800






Hazards method
0.120
0.027
0.022
0.006
0.000
Cumulative hazards
Total
Exogenous
Endogenous
0
28
91
183
274
365
Day


B−P method
0.116
0.027
0.007
0.000
Cum. death fraction
0
28
91
183
274
365
Day

Conclusions

- Good