Estimating relative survival using the *strel* command

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Basis concepts

- Estimation of disease-specific lethality in a group of cancer patients.

- Observed $\text{Probability(death)} = \text{Probability(death from disease of interest)} + \text{Probability(death from all other causes)}$ — Biased estimates of specific mortality as age increases.

- Excess risk of death in study population — reflects impact of disease.

- Net survival probability (complement of excess mortality) — survival probability of cancer when risk of death from other causes has been eliminated.
Method of cause-specific survival

- The cause of each death is assessed.
- Only deaths attributed to the disease under study are counted.
- Other deaths are censored.
- Actuarial method or Kaplan-Meier method.

But

- Strong dependence on the quality of death records.
- Differences in coding the underlying cause of deaths render this method inadvisable for comparisons between registries.
- Arbitrary choice of which causes are considered to be as related to the disease under study.

Relative survival approach

- Concept defined by Berkson (1942) and Berkson & Gage (1950).

\[ Sc(t) = \frac{So(t)}{Se(t)} \]

with \( Sc(t) \) the relative survival probability, \( So(t) \) the observed survival probability, and \( Se(t) \) the expected survival probability.

- Relative survival separates cancer risk and background risk (everyone).

- Minimal requirements:
  - All deaths during the study period are considered.
  - Information on cause of death is not required.
Classical calculation of relative survival

- First methods for the calculation of relative survival provided by Ederer et al. (1959, 1961).

- Vital statistics (life tables) for estimating expected survival probability.

- Expected survival — survival that the patient group would experience if they had the same mortality as that of the general population, given the same initial distribution of prognostic factors.

Choice of appropriate life tables

- Life table should represent the mortality risk that the patients would experience if they did not have the cancer under study.

- Factors with potential influence on life expectancy include:

  - individual (age, sex, socioeconomic status, ethnicity, marital status, …),
  - geographical (region, country, …),
  - time (year or calendar period).

- Relative survival of some patient groups will be biased if these factors are not taken into account.
### Age-Related Death Rates

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Fitted survivor function $l_x$</th>
<th>Mortality rate $\lambda_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>100,000</td>
<td>0.008733</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>99,329</td>
<td>0.000542</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>99,276</td>
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</tr>
<tr>
<td>3</td>
<td>1</td>
<td>99,242</td>
<td>0.000263</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>99,216</td>
<td>0.000211</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>99,195</td>
<td>0.000193</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>99,176</td>
<td>0.000176</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>99,158</td>
<td>0.000158</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>99,143</td>
<td>0.000167</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>99,126</td>
<td>0.000159</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>99,110</td>
<td>0.000159</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>99,096</td>
<td>0.000159</td>
</tr>
<tr>
<td>12</td>
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<td>99,079</td>
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<td>18</td>
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</tr>
<tr>
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<td>1</td>
<td>98,348</td>
<td>0.000753</td>
</tr>
</tbody>
</table>

### Death Rates per 100,000 per Year by Single Year of Age and deprivation category, men, England and Wales, 1990-92

This graph illustrates the death rates per 100,000 per year by single year of age and deprivation category for men in England and Wales from 1990 to 1992.
Interval-specific mortality

Time since diagnosis (years)

Colon cancer - Age group 15-44

Observed mortality
Expected mortality
Relative mortality

Colon cancer - Age group 15-44

Cumulative survival (%)

Time since diagnosis (years)

Observed survival
Expected survival
Relative survival
Interval-specific mortality

Time since diagnosis (years)

Observed mortality
Expected mortality
Relative mortality

Colon cancer - Age group 75+

Cumulative survival (%)

Observed survival
Expected survival
Relative survival

Time since diagnosis (years)
. stset ageout, fail(status=1) enter(time agedtag) id(id)

id:
failure event:  status = 1
obs. time interval:  (ageout[_n-1], ageout)
enter on or after:  time agedtag
exit on or before:  failure

15584  total obs.
0  exclusions
15584  obs. remaining, representing
15584  subjects
10918  failures in single failure-per-subject data
58446,64  total analysis time at risk, at risk from t = 0
earliest observed entry t = 12
latest observed exit t = 107.54

. streg, cph

. strsplit 0.25 1-Fi(1) A(1)10 using popsort strel, merge=close all ab.tri(1)

Iteration 0:  log likelihood = -29046.407
Iteration 1:  log likelihood = -28666.214
Iteration 2:  log likelihood = -28659.857
Iteration 3:  log likelihood = -28659.824
Iteration 4:  log likelihood = -28659.814
Iteration 5:  log likelihood = -28659.814
Iteration 6:  log likelihood = -28659.814
Iteration 7:  log likelihood = -28659.814

Relative survival: estimation of alpha
Number of obs = 30001
Valid chi2(4) = 4288.35
Prob > chi2 = 0.0000

<table>
<thead>
<tr>
<th>Interval</th>
<th>Conf. Std. Err.</th>
<th>z</th>
<th>Pr&gt;z</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval 1</td>
<td>-2.90</td>
<td>0.14</td>
<td>14.27</td>
<td>0.000</td>
</tr>
<tr>
<td>Interval 2</td>
<td>-4.02</td>
<td>0.14</td>
<td>13.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Interval 3</td>
<td>-4.02</td>
<td>0.14</td>
<td>13.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Interval 4</td>
<td>-4.02</td>
<td>0.14</td>
<td>13.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Interval 5</td>
<td>-4.02</td>
<td>0.14</td>
<td>13.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Interval 6</td>
<td>-4.02</td>
<td>0.14</td>
<td>13.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Interval 7</td>
<td>-4.02</td>
<td>0.14</td>
<td>13.13</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Death rates by Interval

. strsplit A(1)10 using popsort strel, merge=close all ab.tri(1)

Command
Survival analysis with different combinations of co-variables

bysort sex year8594 agegrp: ///
    strel 0(0.25)1 1.5(.5)3 4(1)10
    using popmort_strel ///
    , mergeby(_year sex) tr(10) at(1 5 10) nomodel
    saving(colon_strel) replace
Colon cancer - Men, period of diagnosis 1975-84

Excess mortality hazard by age group

- 15-44
- 75+

Time since diagnosis (years)

Relative survival by age group

- 15-44
- 75+

Time since diagnosis (years)
. stset ageout, fail(status==1 2) enter(time agediag) id(id)
. strel 0(0.25)1 1.5(.5)3 4(1)10 using popmort_strel if yydx==1985, mergeby(_year sex) tr(10)
. strel 0(0.25)1 1.5(.5)3 4(1)10 using popmort_strel, mergeby(_year sex) tr(10) period(1985) diag(dx)
strel: main options

• *by* option

• Prediction of survival
  period and *hybrid* approaches

• adjustment for variable(s)
  conventional standardisation
  individual adjustment

References

• Relative survival
  - Estève J, Benhamou E, Raymond L. Statistical methods in cancer
    research (Vol. 4): Descriptive epidemiology. IARC Scientific

• Period and hybrid approaches
  - Brenner H, Gefeller O. An alternative approach to monitoring
  - Brenner H, Rachet B. Hybrid analysis for up-to-date long-term
    survival rates in cancer registries with delayed recording of incident

• Individual adjustment
  - Brenner H, Arndt V, Gefeller O, Hakulinen T. An alternative
    approach to age adjustment of cancer survival rates. *Eur J Cancer*