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 Probability(death) = Probability(death from disease of interest) + 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).
- At each time t, $Sc(t) = \frac{So(t)}{Se(t)}$

  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

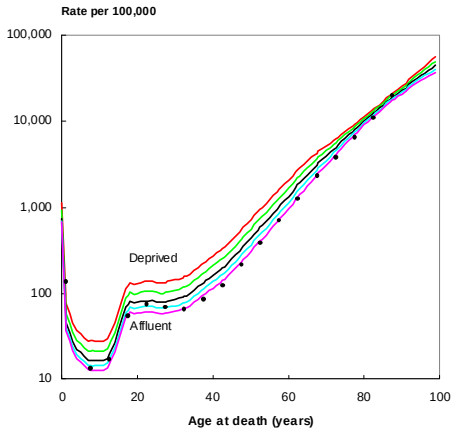
- First methods for the calculation of relative survival provided by Ederer *et al.* (1959, 1961).
- Vital statistics (life tables) for estimating expected survival probability.
- Expected survival — survival that the patient group would experience if they had the same mortality as that of the general population, given the same *initial* distribution of prognostic factors.

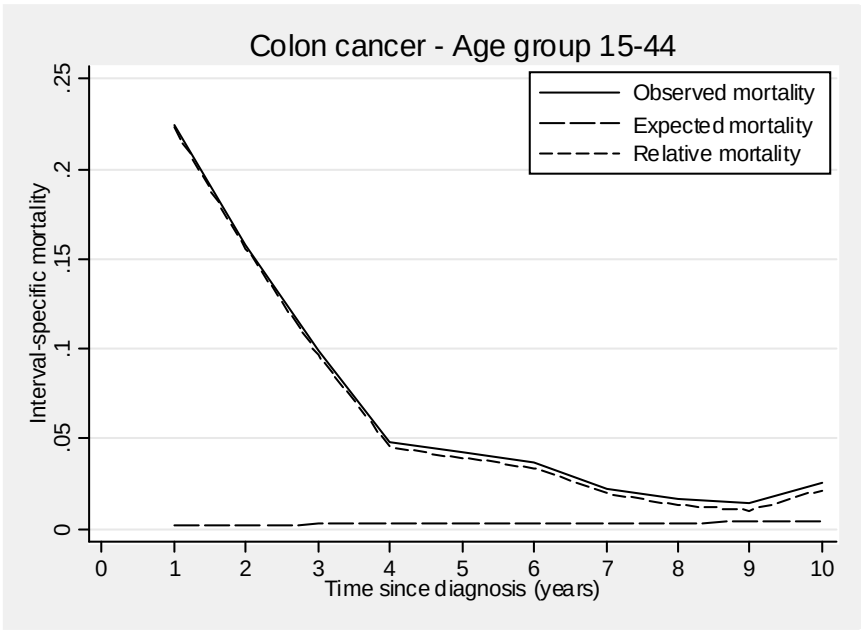
Choice of appropriate life tables

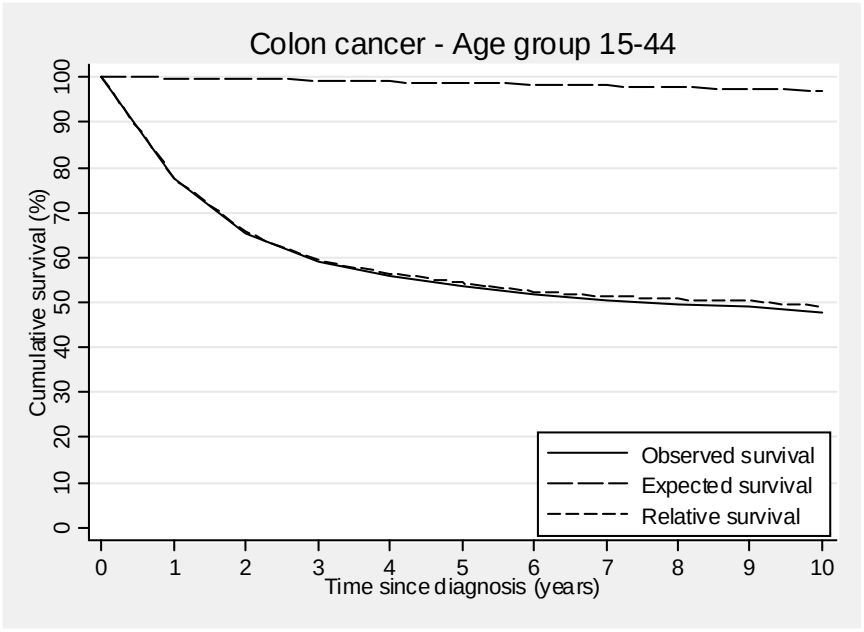
- Life table should represent the mortality risk that the patients would experience if they did not have the cancer under study.
- Factors with potential influence on life expectancy include:
  - individual (age, sex, socioeconomic status, ethnicity, marital status, …),
  - geographical (region, country, …),
  - time (year or calendar period).
- Relative survival of some patient groups will be biased if these factors are not taken into account.

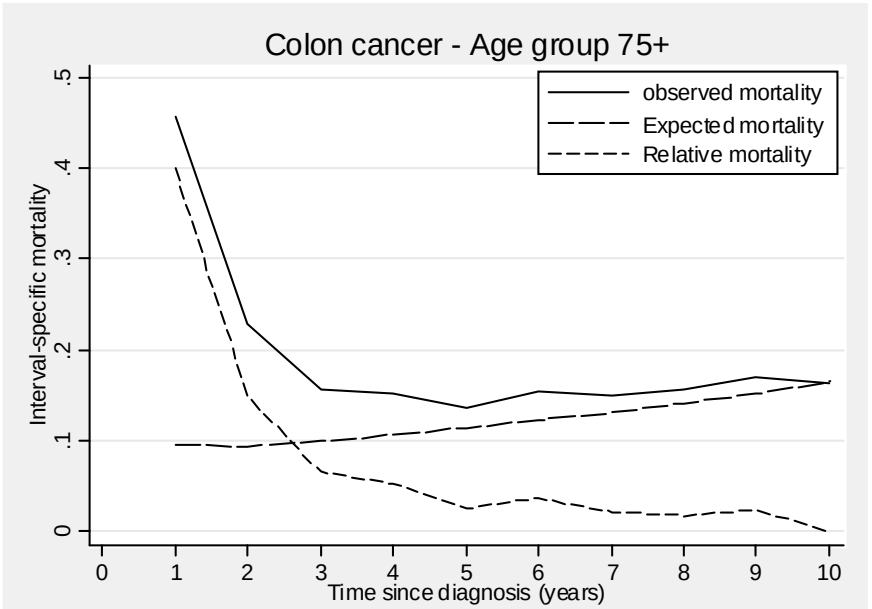
Age x	Sex	Fitted survivor function l_x	Mortality rate λ_x
0	1	100,000	0.006733
1	1	99,329	0.000542
2	1	99,275	0.000333
3	1	99,242	0.000263
4	1	99,216	0.000211
5	1	99,195	0.000193
6	1	99,176	0.000176
7	1	99,158	0.000158
8	1	99,143	0.000167
9	1	99,126	0.000159
10	1	99,110	0.000159
11	1	99,095	0.000159
12	1	99,079	0.000168
13	1	99,062	0.000203
14	1	99,042	0.000256
15	1	99,017	0.000345
16	1	98,983	0.000460
17	1	98,937	0.000656
18	1	98,872	0.000764
19	1	98,797	0.000721
20	1	98,726	0.000739
21	1	98,653	0.000758
22	1	98,578	0.000777
23	1	98,501	0.000778
24	1	98,425	0.000779
25	1	98,348	0.000753

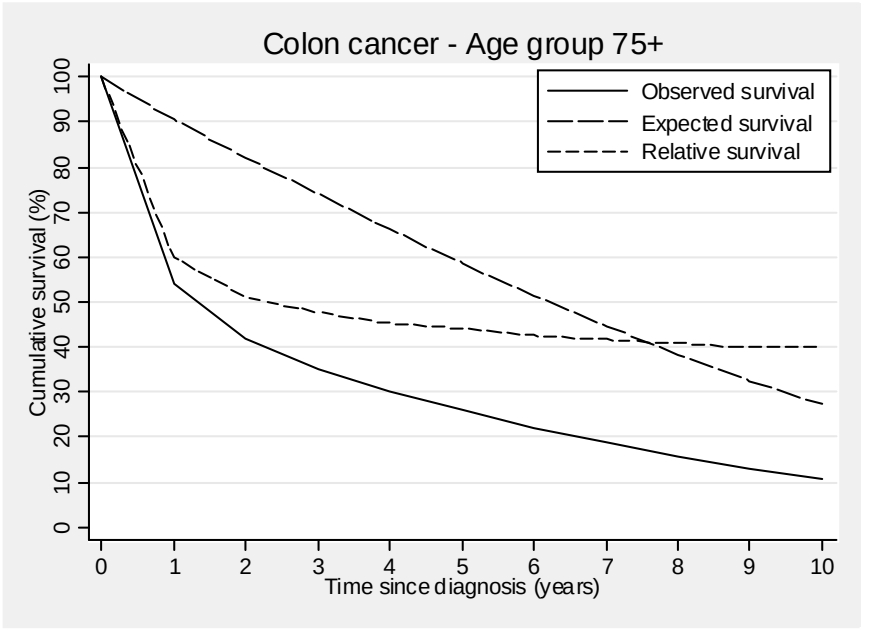
Death rates per 100,000 per year by single year of age and deprivation category, men, England and Wales, 1990-92

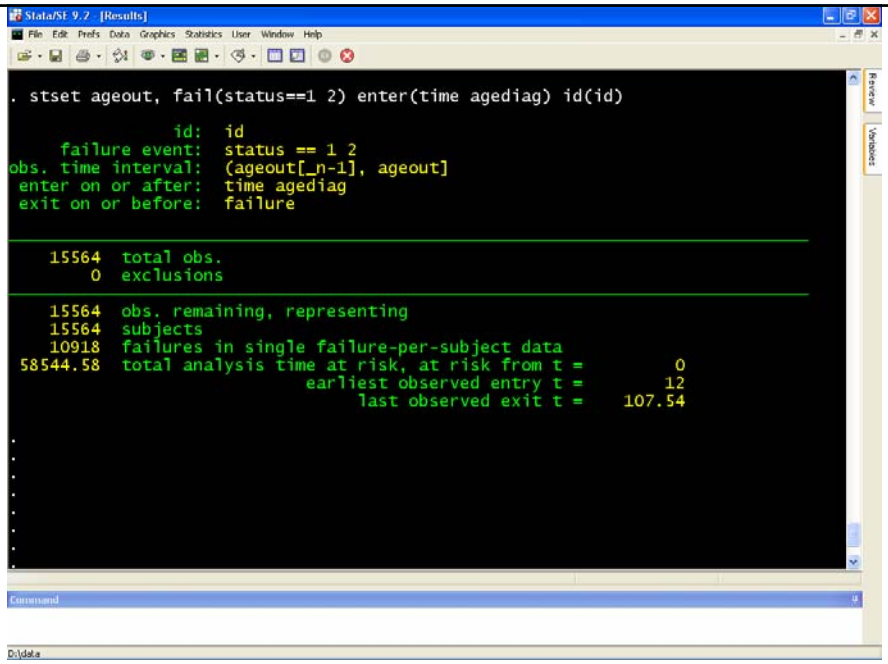


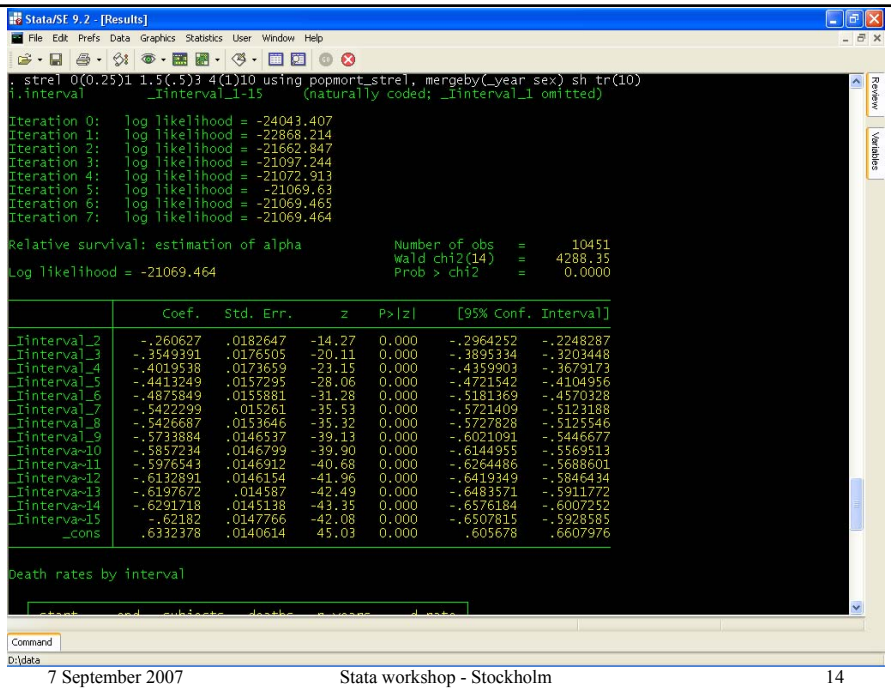

Colon cancer - Age group 15-44
Observed mortality
Expected mortality
Relative mortality
Interval-specific mortality
0
.05
.1
.15
.2
.25
0
1
2
3
4
5
6
7
8
9
10
Time since diagnosis (years)

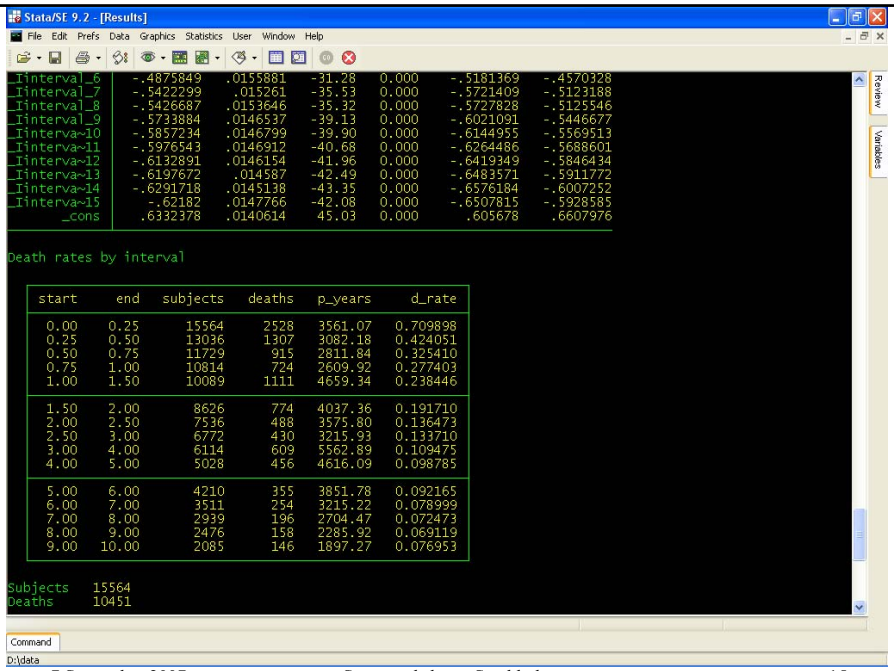

Colon cancer - Age group 15-44
Observed survival
Expected survival
Relative survival
Cumulative survival (%)
0
10
20
30
40
50
60
70
80
90
100
0
1
2
3
4
5
6
7
8
9
10
Time since diagnosis (years)

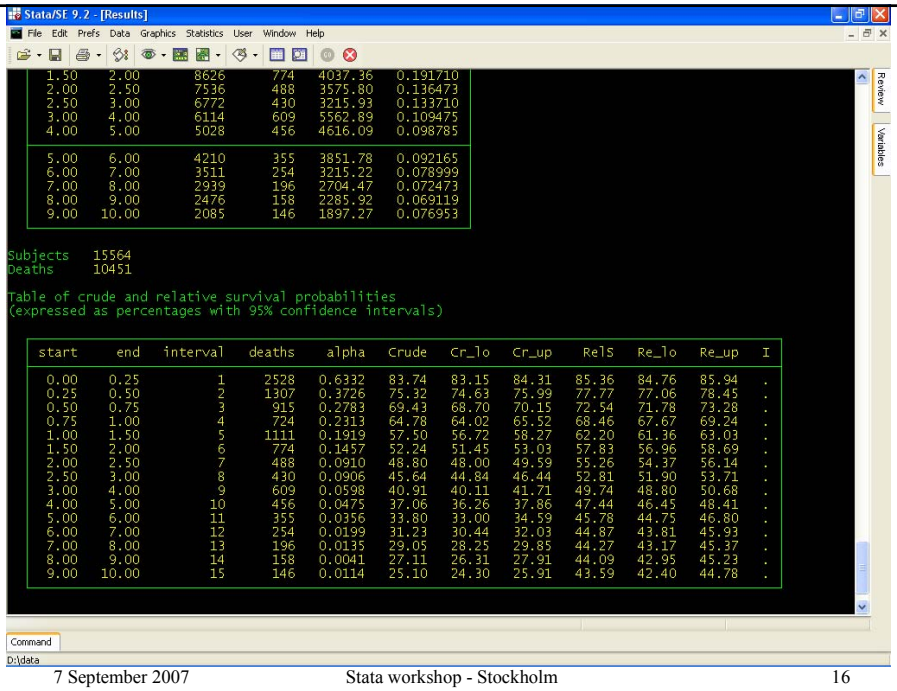

Colon cancer - Age group 75+
observed mortality
Expected mortality
Relative mortality
Interval-specific mortality
0
.1
.2
.3
.4
.5
0
1
2
3
4
5
6
7
8
9
10
Time since diagnosis (years)


Colon cancer - Age group 75+
Observed survival
Expected survival
Relative survival
Cumulative survival (%)
0
10
20
30
40
50
60
70
80
90
100
0
1
2
3
4
5
6
7
8
9
10
Time since diagnosis (years)


Stata/SE 9.2 - [Results]
File Edit Prefs Data Graphics Statistics User Window Help
. stset ageout, fail(status==1 2) enter(time agediag) id(id)
id: id
failure event: status == 1 2
obs. time interval: (ageout[_n-1], ageout]
enter on or after: time agediag
exit on or before: failure
15564 total obs.
0 exclusions
15564 obs. remaining, representing
15564 subjects
10918 failures in single failure-per-subject data
58544.58 total analysis time at risk, at risk from t = 0
earliest observed entry t = 12
last observed exit t = 107.54
Review
Variables
Command
D:\data

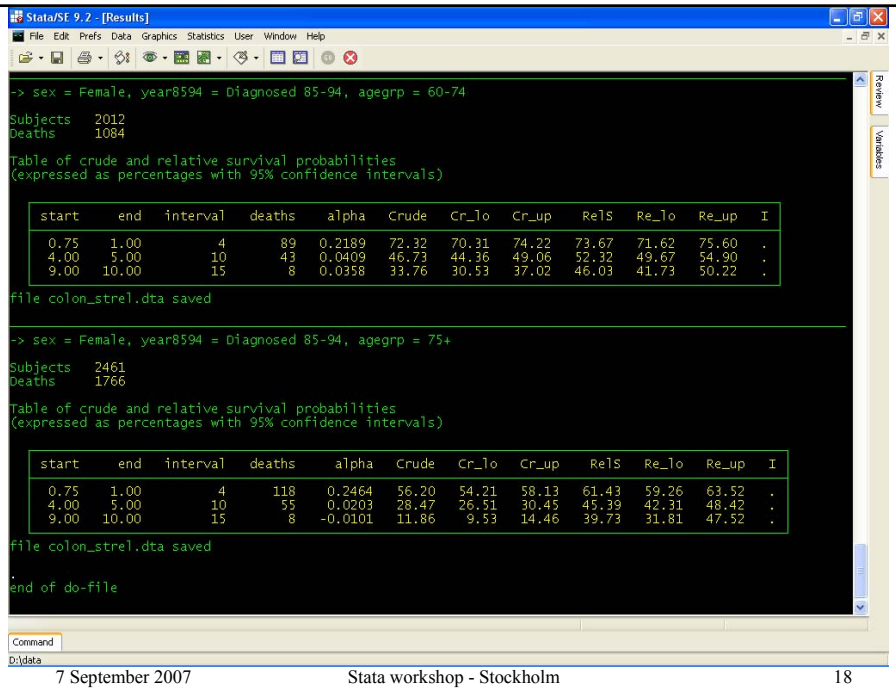

Stata/SE 9.2 - [Results]
File Edit Prefs Data Graphics Statistics User Window Help
. strel 0(0.25)1 1.5(.5)3 4(1)10 using popmort_strel, mergeby(_year sex) sh tr(10)
i.interval _Iinterval_1-15 (naturally coded; _Iinterval_1 omitted)
Iteration 0: log likelihood = -24043.407
Iteration 1: log likelihood = -22868.214
Iteration 2: log likelihood = -21662.847
Iteration 3: log likelihood = -21097.244
Iteration 4: log likelihood = -21072.913
Iteration 5: log likelihood = -21069.63
Iteration 6: log likelihood = -21069.465
Iteration 7: log likelihood = -21069.464
Relative survival: estimation of alpha
Number of obs = 10451
Wald chi2(14) = 4288.35
Log likelihood = -21069.464
Prob > chi2 = 0.0000
Coef. Std. Err. z P>|z| [95% Conf. Interval]
_Iinterval_2 -.260627 .0182647 -14.27 0.000 -.2964252 -.2248287
_Iinterval_3 -.3549391 .0176505 -20.11 0.000 -.3895334 -.3203448
_Iinterval_4 -.4019538 .0173659 -23.15 0.000 -.4359903 -.3679173
_Iinterval_5 -.4413249 .0157295 -28.06 0.000 -.4721542 -.4104956
_Iinterval_6 -.4875849 .0155881 -31.28 0.000 -.5181369 -.4570328
_Iinterval_7 -.5422299 .015261 -35.53 0.000 -.5721409 -.5123188
_Iinterval_8 -.5426687 .0153646 -35.32 0.000 -.5727828 -.5125546
_Iinterval_9 -.5733884 .0146537 -39.13 0.000 -.6021091 -.5446677
_Iinterva~10 -.5857234 .0146799 -39.90 0.000 -.6144955 -.5569513
_Iinterva~11 -.5976543 .0146912 -40.68 0.000 -.6264486 -.5688601
_Iinterva~12 -.6132891 .0146154 -41.96 0.000 -.6419349 -.5846434
_Iinterva~13 -.6197672 .014587 -42.49 0.000 -.6483571 -.5911772
_Iinterva~14 -.6291718 .0145138 -43.35 0.000 -.6576184 -.6007252
_Iinterva~15 -.62182 .0147766 -42.08 0.000 -.6507815 -.5928585
_cons .6332378 .0140614 45.03 0.000 .605678 .6607976
Death rates by interval
Review
Variables
Command
D:\data

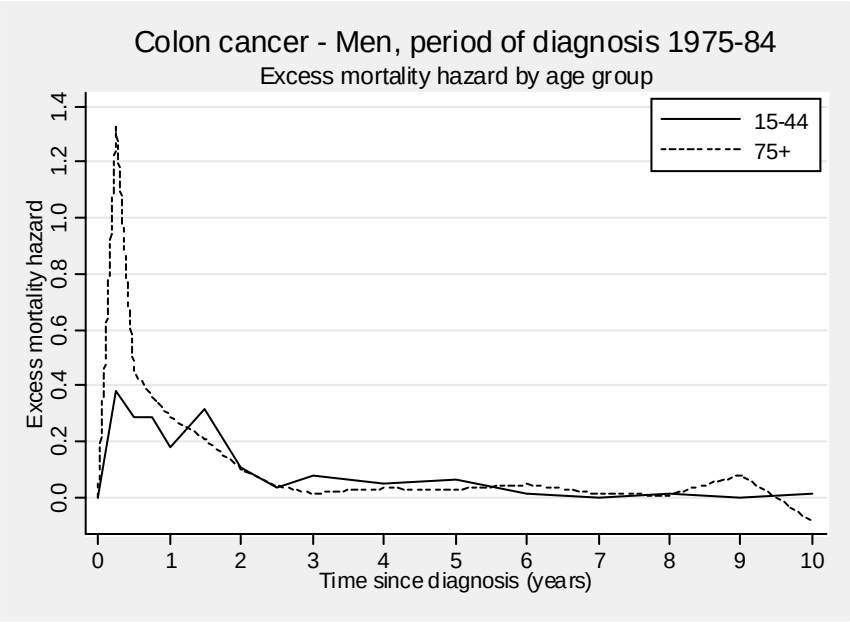

Stata/SE 9.2 - [Results]
File Edit Prefs Data Graphics Statistics User Window Help
_Iinterval_6 -.4875849 .0155881 -31.28 0.000 -.5181369 -.4570328
_Iinterval_7 -.5422299 .015261 -35.53 0.000 -.5721409 -.5123188
_Iinterval_8 -.5426687 .0153646 -35.32 0.000 -.5727828 -.5125546
_Iinterval_9 -.5733884 .0146537 -39.13 0.000 -.6021091 -.5446677
_Iinterva~10 -.5857234 .0146799 -39.90 0.000 -.6144955 -.5569513
_Iinterva~11 -.5976543 .0146912 -40.68 0.000 -.6264486 -.5688601
_Iinterva~12 -.6132891 .0146154 -41.96 0.000 -.6419349 -.5846434
_Iinterva~13 -.6197672 .014587 -42.49 0.000 -.6483571 -.5911772
_Iinterva~14 -.6291718 .0145138 -43.35 0.000 -.6576184 -.6007252
_Iinterva~15 -.62182 .0147766 -42.08 0.000 -.6507815 -.5928585
_cons .6332378 .0140614 45.03 0.000 .605678 .6607976
Death rates by interval
start end subjects deaths p_years d_rate
0.00 0.25 15564 2528 3561.07 0.709898
0.25 0.50 13036 1307 3082.18 0.424051
0.50 0.75 11729 915 2811.84 0.325410
0.75 1.00 10814 724 2609.92 0.277403
1.00 1.50 10089 1111 4659.34 0.238446
1.50 2.00 8626 774 4037.36 0.191710
2.00 2.50 7536 488 3575.80 0.136473
2.50 3.00 6772 430 3215.93 0.133710
3.00 4.00 6114 609 5562.89 0.109475
4.00 5.00 5028 456 4616.09 0.098785
5.00 6.00 4210 355 3851.78 0.092165
6.00 7.00 3511 254 3215.22 0.078999
7.00 8.00 2939 196 2704.47 0.072473
8.00 9.00 2476 158 2285.92 0.069119
9.00 10.00 2085 146 1897.27 0.076953
Subjects 15564
Deaths 10451
Command
D:\data


Stata/SE 9.2 - [Results]
File Edit Prefs Data Graphics Statistics User Window Help
1.50 2.00 8626 774 4037.36 0.191710
2.00 2.50 7536 488 3575.80 0.136473
2.50 3.00 6772 430 3215.93 0.133710
3.00 4.00 6114 609 5562.89 0.109475
4.00 5.00 5028 456 4616.09 0.098785
5.00 6.00 4210 355 3851.78 0.092165
6.00 7.00 3511 254 3215.22 0.078999
7.00 8.00 2939 196 2704.47 0.072473
8.00 9.00 2476 158 2285.92 0.069119
9.00 10.00 2085 146 1897.27 0.076953
Subjects 15564
Deaths 10451
Table of crude and relative survival probabilities
(expressed as percentages with 95% confidence intervals)
start end interval deaths alpha Crude Cr_lo Cr_up RelS Re_lo Re_up I
0.00 0.25 1 2528 0.6332 83.74 83.15 84.31 85.36 84.76 85.94 .
0.25 0.50 2 1307 0.3726 75.32 74.63 75.99 77.77 77.06 78.45 .
0.50 0.75 3 915 0.2783 69.43 68.70 70.15 72.54 71.78 73.28 .
0.75 1.00 4 724 0.2313 64.78 64.02 65.52 68.46 67.67 69.24 .
1.00 1.50 5 1111 0.1919 57.50 56.72 58.27 62.20 61.36 63.03 .
1.50 2.00 6 774 0.1457 52.24 51.45 53.03 57.83 56.96 58.69 .
2.00 2.50 7 488 0.0910 48.80 48.00 49.59 55.26 54.37 56.14 .
2.50 3.00 8 430 0.0906 45.64 44.84 46.44 52.81 51.90 53.71 .
3.00 4.00 9 609 0.0598 40.91 40.11 41.71 49.74 48.80 50.68 .
4.00 5.00 10 456 0.0475 37.06 36.26 37.86 47.44 46.45 48.41 .
5.00 6.00 11 355 0.0356 33.80 33.00 34.59 45.78 44.75 46.80 .
6.00 7.00 12 254 0.0199 31.23 30.44 32.03 44.87 43.81 45.93 .
7.00 8.00 13 196 0.0135 29.05 28.25 29.85 44.27 43.17 45.37 .
8.00 9.00 14 158 0.0041 27.11 26.31 27.91 44.09 42.95 45.23 .
9.00 10.00 15 146 0.0114 25.10 24.30 25.91 43.59 42.40 44.78 .
Command
D:\data

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
```



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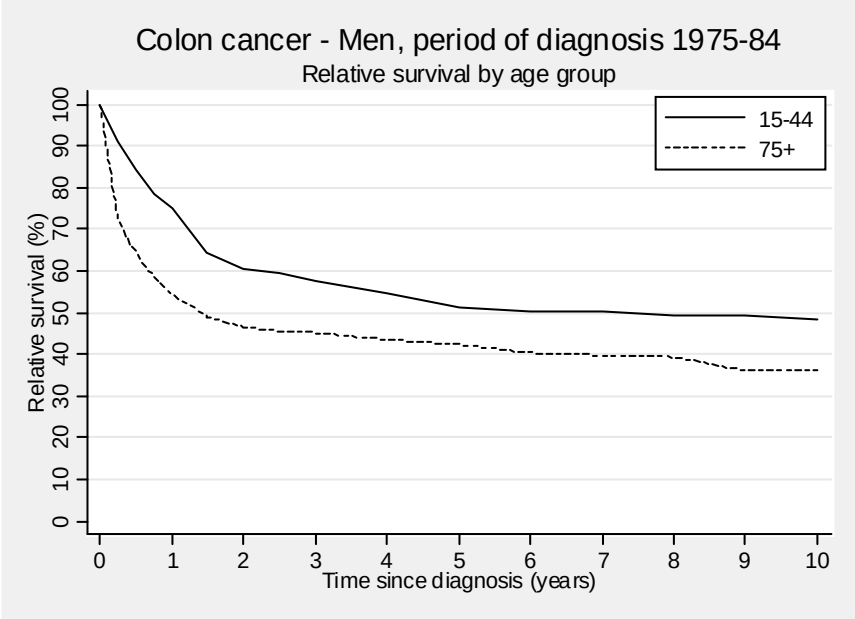

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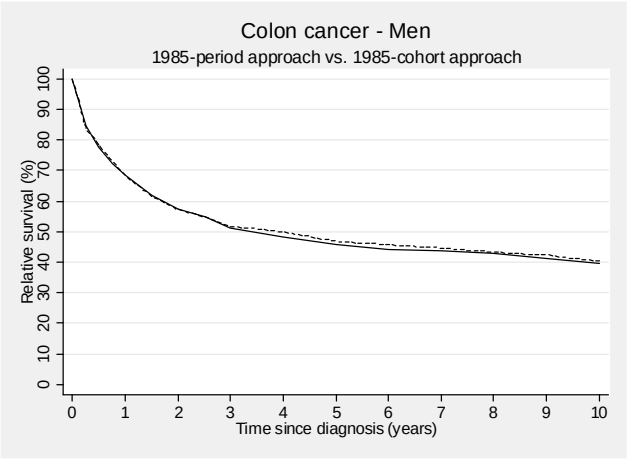
Years of diagnosis	Years of follow-up															
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	
1975	A 1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10					B
1976		1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10				
1977			1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10			
1978				1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10		
1979					1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10	
1980	C					1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	D
1981							1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	
1982								1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	
1983									1	1/2	2/3	3/4	4/5	5/6	6/7	
1984										1	1/2	2/3	3/4	4/5	5/6	
1985											1	1/2	2/3	3/4	4/5	E
1986												1	1/2	2/3	3/4	
1987													1	1/2	2/3	
1988														1	1/2	
1989															1	


```
. 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 Publications, No 128, Lyon, IARC, 1994.
- Period and hybrid approaches
  - Brenner H, Gefeller O. An alternative approach to monitoring cancer patient survival. *Cancer* 1996;78:2004-2010.
  - Brenner H, Rachet B. Hybrid analysis for up-to-date long-term survival rates in cancer registries with delayed recording of incident cases. *Eur J Cancer* 2004;40:2494-2501.
- Individual adjustment
  - Brenner H, Arndt V, Gefeller O, Hakulinen T. An alternative approach to age adjustment of cancer survival rates. *Eur J Cancer* 2004;40:2317-2322.