Estimating Expected Survival Probabilities for Relative Survival Analysis – Exploring the Impact of Including Cancer Patient Mortality from the Calculations

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Definition of relative survival

Relative survival

Observed survival of the cancer patients divided by the expected survival of a comparable group (with respect to age, sex, race, etc.) free from the cancer under study [1].

- Assume for now that the general population is 'comparable' with respect to non-cancer mortality (within categories of age, sex, year, etc.).
- We will explore the magnitude of the bias caused by using a general population that is not 'free from the cancer under study'.
- Paper in European Journal of Cancer 2011 [2].

The current state of knowledge [1]

Use of Population Life Tables

The expected survival rate was defined as the rate for a population similar to the patient group, but *free of the specific disease under study*. Life tables published by the National Office of Vital Statistics are a readily available source of information from which expected survival rates may be estimated. The life-table population may be looked upon as a control group.

Since population life tables reflect the force of mortality from all causes of death, it would seem desirable to adjust the life-table values so as to eliminate deaths due to the disease under study. In practice, this is rarely necessary. Berkson and Gage (*7*, *12*) and Cutler *et al.* (*14*) have argued that mortality for a specific site constitutes a negligible fraction of total mortality and that, therefore, survival rates computed from general population life tables provide satisfactory estimates of expected rates in analyzing survival of patients with cancer of a specific site. Mil-

Material and methods

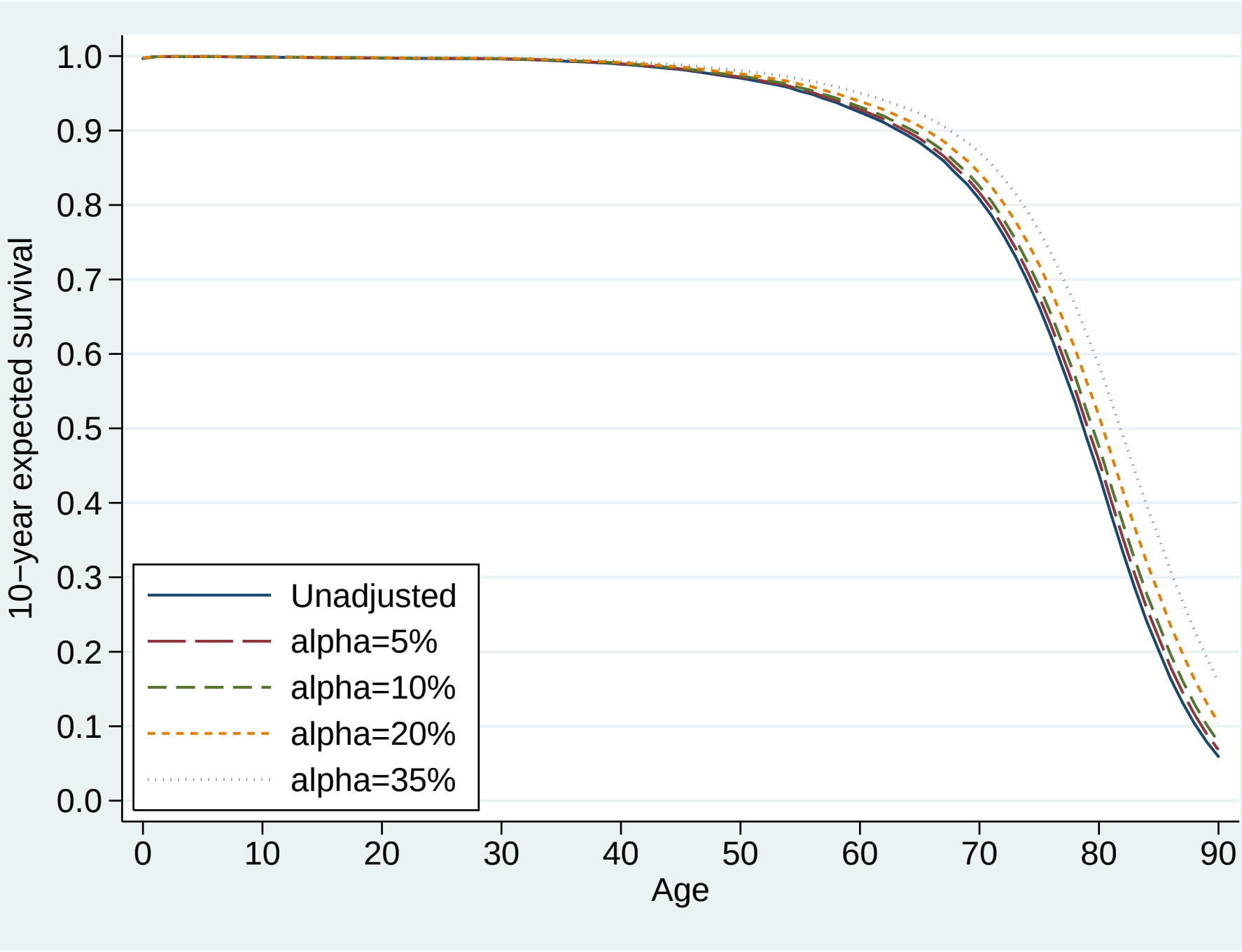
- Using computerised population registers in Sweden, we had the opportunity to calculate expected survival both including and excluding individuals with cancer, and thereby estimate the size of the bias arising from using general population life tables.
- Estimates of expected survival using the 'gold standard' were obtained based on individual population data where risk time was censored at the date of cancer diagnosis.
- We also evaluated a simple method to adjust expected survival probabilities estimated from general population statistics as an aid to researchers who do not have access to computerised registers of the population.

A simple correction

- If we know the proportion of deaths in the general population due to the specific cancer, we can correct expected survival.
- The corrected expected survival proportion is given by

$$p^*_{\text{corrected}} = p^*_{\text{uncorrected}}{}^{(1-\alpha)}$$

  where α is the proportion of deaths due to the specific cancer in the general population.
- $\alpha = 0$ implies $p^*_{\text{corrected}} = p^*_{\text{uncorrected}}$ (i.e., no bias).
- $\alpha = 1$ implies $p^*_{\text{corrected}} = 1$
  (i.e., if everyone dies of the specific cancer then everyone must survive in the absence of that cancer).
- Preferable to estimate α within age groups (e.g., 5 years).


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10−year expected survival
0
10
20
30
40
50
60
70
80
90
Age
Unadjusted
alpha=5%
alpha=10%
alpha=20%
alpha=35%

Percentage of deaths due to cancer in Sweden 2008

Age	All sites	Colorectal	Lung	Skin	Breast	Prostate
all	23.8	2.9	3.9	0.6	3.2	5.6
< 1	0.4	0.0	0.0	0.0	0.0	0.0
$1 - 4$	17.2	0.0	0.0	0.0	0.0	0.0
$5 - 14$	19.3	0.0	0.0	0.0	0.0	0.0
$15 - 24$	8.5	0.0	0.0	0.7	0.0	0.0
$25 - 34$	15.6	1.5	0.6	1.0	6.0	0.0
$35 - 44$	29.6	3.4	2.5	2.6	11.6	0.1
$45 - 54$	38.2	3.7	6.0	1.7	15.0	1.1
$55 - 64$	42.9	4.5	9.9	1.3	10.0	3.0
$65 - 74$	41.5	5.1	8.7	1.0	6.3	5.4
$75 - 84$	26.1	3.4	4.2	0.5	2.8	7.2
$85 - 94$	13.0	1.8	1.1	0.3	1.4	6.4
$95+$	4.6	0.7	0.1	0.2	0.9	3.7

Results: All sites combined, both sexes

Age	Method	Years since diagnosis 1	2	5	10	15
0–w	RSR (Gold standard)	66.7	58.2	47.6	40.8	38.7
	Bias with usual method	0.6	1.0	2.0	3.3	4.3
	Bias after correction	0.0	0.1	0.1	0.1	-0.1
0–54	RSR (Gold standard)	84.2	77	67.2	60.7	57.2
	Bias with usual method	0.1	0.1	0.3	0.8	1.4
	Bias after correction	0.0	0.0	0.0	0.0	0.0
55–74	RSR (Gold standard)	68.4	58.7	46.6	37.9	33.3
	Bias with usual method	0.5	0.8	1.8	3.3	4.7
	Bias after correction	0.0	0.1	0.1	0.1	0.0
75–w	RSR (Gold standard)	55.7	47.7	36.4	26.8	22.1
	Bias with usual method	0.9	1.6	3.0	4.5	5.5
	Bias after correction	0.1	0.1	0.1	-0.2	-0.7

Results: Colorectal cancer, both sexes

Age	Method	Years since diagnosis 1	2	5	10	15
0–w	RSR (Gold standard)	70.0	60.5	47.9	42.4	40.9
	Bias with usual method	0.1	0.2	0.3	0.5	0.6
	Bias after correction	0.0	0.0	0.0	0.0	0.0
0–54	RSR (Gold standard)	81.4	72.1	60.9	56.2	53.4
	Bias with usual method	0.0	0.0	0.0	0.1	0.1
	Bias after correction	0.0	0.0	0.0	0.0	0.0
55–74	RSR (Gold standard)	75.7	65.0	49.2	42.1	40.4
	Bias with usual method	0.1	0.1	0.2	0.4	0.6
	Bias after correction	0.0	0.0	0.0	0.0	0.0
75–w	RSR (Gold standard)	61.0	52.3	42.2	36.7	31.5
	Bias with usual method	0.1	0.2	0.5	0.8	1.0
	Bias after correction	0.0	0.0	0.0	0.0	0.0

Results: Lung cancer, both sexes

		Years since diagnosis				
Age	Method	1	2	5	10	15
0–w	RSR (Gold standard)	27.2	13.5	8.0	5.6	4.8
	Bias with usual method	0.0	0.0	0.1	0.1	0.1
	Bias after correction	0.0	0.0	0.0	0.0	0.0
0–54	RSR (Gold standard)	37.7	20.4	10.7	8.7	7.0
	Bias with usual method	0.0	0.0	0.0	0.0	0.0
	Bias after correction	0.0	0.0	0.0	0.0	0.0
55–74	RSR (Gold standard)	30.7	15.2	9.0	5.6	4.5
	Bias with usual method	0.0	0.0	0.1	0.1	0.1
	Bias after correction	0.0	0.0	0.0	0.0	0.0
75–w	RSR (Gold standard)	15.8	6.8	3.9	2.6	2.4
	Bias with usual method	0.0	0.0	0.0	0.0	0.1
	Bias after correction	0.0	0.0	0.0	0.0	0.0

Results: Malignant skin cancer, both sexes

		Years since diagnosis				
Age	Method	1	2	5	10	15
0–w	RSR (Gold standard)	95.4	91.2	84.3	77.9	77.1
	Bias with usual method	0.0	0.0	0.1	0.1	0.2
	Bias after correction	0.0	0.0	0.0	0.1	0.1
0–54	RSR (Gold standard)	97.0	93.4	87.4	83.0	80.0
	Bias with usual method	0.0	0.0	0.0	0.0	0.0
	Bias after correction	0.0	0.0	0.0	0.0	0.0
55–74	RSR (Gold standard)	95.7	91.2	85.8	80.3	80.7
	Bias with usual method	0.0	0.0	0.1	0.2	0.3
	Bias after correction	0.0	0.0	0.0	0.1	0.1
75–w	RSR (Gold standard)	94.2	90.1	80.8	68.1	67.2
	Bias with usual method	0.0	0.1	0.2	0.3	0.4
	Bias after correction	0.0	0.0	0.1	0.2	0.2

Results: Breast cancer (females)

Age	Method	Years since diagnosis 1	2	5	10	15
0–w	RSR (Gold standard)	94.7	90.5	78.8	68.2	62.1
	Bias with usual method	0.1	0.2	0.4	0.6	0.8
	Bias after correction	0.0	0.0	0.1	0.1	0.1
0–54	RSR (Gold standard)	97.4	93.5	80.5	69.2	63.6
	Bias with usual method	0.0	0.1	0.1	0.3	0.4
	Bias after correction	0.0	0.0	0.0	0.0	0.0
55–74	RSR (Gold standard)	95.3	91.1	80.9	71.5	64.9
	Bias with usual method	0.1	0.2	0.4	0.7	0.9
	Bias after correction	0.0	0.0	0.0	0.1	0.1
75–w	RSR (Gold standard)	90.8	85.9	71.6	54.6	41.4
	Bias with usual method	0.2	0.3	0.7	1.2	1.4
	Bias after correction	0.1	0.1	0.2	0.4	0.3

Results: Prostate cancer

Age	Method	Years since diagnosis 1	2	5	10	15
0–w	RSR (Gold standard)	85.8	77.7	59.5	42.6	31.9
	Bias with usual method	0.3	0.5	1.0	1.5	1.7
	Bias after correction	0.0	0.1	0.1	0.1	0.0
0–54	RSR (Gold standard)	87.6	86.4	48.3	38.2	29.6
	Bias with usual method	0.0	0.0	0.0	0.0	0.1
	Bias after correction	0.0	0.0	0.0	0.0	0.0
55–74	RSR (Gold standard)	89.9	81.3	63.1	45.1	33.4
	Bias with usual method	0.2	0.3	0.6	1.2	1.6
	Bias after correction	0.0	0.0	0.1	0.1	0.0
75–w	RSR (Gold standard)	81.4	73.5	55.2	38.6	29.7
	Bias with usual method	0.4	0.8	1.7	2.6	3.3
	Bias after correction	0.0	0.1	0.1	0.0	-0.4

Conclusions

- Our results show that the bias is sufficiently small to be ignorable for most applications, notably for cancers with high or low mortality and for younger age groups.
- However, the bias in relative survival estimates can be greater than 1 percent unit for older age groups for common cancers and even larger for all sites combined.
- For example, the bias in 10-year relative survival for men aged 75+ diagnosed with prostate cancer was 2.6 percent units, which we think is of sufficient magnitude to warrant adjustment.

References

[1] Ederer F, Axtell L, Cutler S. The relative survival rate: A statistical methodology. *National Cancer Institute Monograph* 1961;**6**:101–121.

[2] Talbäck M, Dickman PW. Estimating expected survival probabilities for relative survival analysis - exploring the impact of including cancer patient mortality in the calculations. *Eur J Cancer* 2011;**47**:2626–32.