Cancer in Norway 2018

Technical Supplement: Statistical Methods

Department of Registration
Section for Analysis and Research

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Cancer Registry of Norway

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1 Statistical methods

1.1 Target readership

The target readership for this technical supplement include statisticians and cancer epidemiologists.

1.2 Incidence and mortality rates

Rates are used to measure the frequency at which an event occurs in a defined population during a defined time period. Rates facilitate comparisons across groups of different sizes. Let d and Y denote the number of events and the number of person-years in the population, respectively. In Cancer in Norway 2018 (CIN2018) the mid-year population Y is calculated as the arithmetic mean of the population at the start and end of each calendar year. If the interest lies in calculating a rate over a period of more than one year, we first calculate the annual mid-year population, and then aggregate to determine the total number of person-years.

Rates are reported both as age-specific rates and age-standardised rates (ASR) per 100,000 person-years. The population is divided into 18 distinct five-year age groups. Let d_i and Y_i denote the number of events and the total number of person-years, respectively, for age group i. The age-specific rate r_i per 100,000 person-years, for age group i is then given by

$$r_i = \frac{d_i}{Y_i} \cdot 10^5 \tag{1}$$

The age-standardised rate is calculated as

$$ASR = \frac{\sum\limits_{i=1}^{18} w_i r_i}{\sum\limits_{i=1}^{18} w_i} \tag{2}$$

where w_i is a weight, for age group i, given by the reference population.

Typically the World Standard Population has been used (Doll & al, 1966). CIN2018 uses the age distribution of the Norwegian 2014 mid-year population as the standard population. The population weights for the World Standard Population and the Norwegian 2014 population are given in the table below. One should

note that the World Standard Population places a higher weight on younger age groups and a lower weight on older age groups compared to the 2014 Norwegian population.

i	Age	World (Doll/Segi)	Norway (2014)
1	0–4	12,000	6,039
2	5–9	10,000	6,102
3	10–14	9,000	5,993
4	15–19	9,000	6,349
5	20–24	8,000	6,681
6	25–29	8,000	6,770
7	30–34	6,000	6,690
8	35–39	6,000	6,670
9	40–44	6,000	7,296
10	45–49	6,000	7,207
11	50–54	5,000	6,492
12	55–59	4,000	6,108
13	60–64	4,000	5,575
14	65–69	3,000	5,369
15	70–74	2,000	3,702
16	75–79	1,000	2,663
17	80–84	500	2,063
18	85+	500	2,231
Sum		100,000	100,000

1.3 Cumulative risk

Cumulative risk (CR) is an estimate of the risk of developing a certain type of cancer by a given age. In CIN2018 CR is estimated up to the age of 74. It is defined as

$$CR = 1 - e^{-\left(5 \sum_{i=1}^{N} r_i\right)} \tag{3}$$

where i denotes age group and N denotes the number of age groups used.

1.4 Prevalence

Prevalence is calculated as the number of people in the population that are alive and have been diagnosed with the cancer of interest at some point during their

lifetime.

1.5   Relative survival (net survival)

Net survival is estimated by the relative survival ratio, $R(t)$, defined by

$$R(t) = \frac{S_O(t)}{S_E(t)} \tag{4}$$

where $S_O(t)$ is the observed survival at time t and $S_E(t)$ is the expected survival at time t. Observed survival is calculated using the actuarial method (also frequently called the life table method). The period of interest is divided into k time intervals, where interval $i \in [t_{i-1}, t_i)$. Let l_i, d_i and c_i denote the number of persons alive at the start of interval i, the number of deaths during interval i and the number of censored individuals during interval i, respectively. Assuming that censoring occurs uniformly throughout each time interval, the observed cumulative survival is calculated as

$$S_O(t) = \prod_{i=1}^{k} p_i \tag{5}$$

where p_i denotes the interval-specific observed survival, given by $p_i = \left(1 - \frac{d_i}{l_i'}\right)$, and $l_i' = l_i - \frac{1}{2}c_i$ is the effective number at risk in interval i.

When the period approach is used, the estimate of the interval-specific observed survival is calculated by transforming the estimated cumulative hazard, $p_i = \exp\{b_i \cdot (-d_i/y_i)\}$. Here b_i is the width of the interval and y_i is the person-time at risk in the interval.

Cumulative expected survival is calculated using the Ederer II estimator (Ederer, 1959)

$$S_E(t) = \prod_{i=1}^{k} p_i^E \tag{6}$$

where

$$p_i^E = \sum_{h=1}^{l_i} \frac{p_i(h)}{l_i}$$

denotes the interval-specific expected survival obtained by averaging the annual expected survival probabilities, $p_i(h)$, of the patients alive at the start of interval i. The individual expected survival is obtained using national unsmoothed population life tables matched on sex, age, and calendar year.

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To reduce the potential for bias and to facilitate comparisons over time, the net survival estimate must be age-standardised. Let $R_j(t)$ denote the relative survival of patients in age group j, and assume we have s distinct age groups, then an age-standardised estimate of net survival, denoted $R_s(t)$ is given by

$$R_s(t) = \sum_{j=1}^{s} w_j R_j(t) \tag{7}$$

where w_j is the weight for age group j. These weights are determined, for each group of diagnosis and sex, by the age distribution of the patients diagnosed during the most recent five-year period 2014–2018.

Ideally it is better to have more age groups than fewer, and to use more narrow age groups for older patients. However, in practice, when splitting data in many age groups we will run out of patients during the follow-up period in one or more age groups, and an age-standardised estimate will be unobtainable. We calculate age-standardised estimates of net survival by dividing patients into three distinct age groups, defined by the tertiles of the age distribution in the most recent five-year period of diagnosis. This approach reduces the probability of age-standardised estimates being unobtainable. For less frequent and more lethal cancer sites we still cannot avoid sparse data, particularly when estimating five-year net survival.

As mentioned in the section *Statistical Methods* in *Cancer in Norway 2018*, the cohort method is used when follow-up is complete. The period approach is used to obtain estimates for most recent five-year period and the most recent year when analysing trends. When analysing trends relative survival estimates for the years 2014–2017 are obtained using a mixture of the cohort and period approach. This is done to avoid artifical changes in the trend curves when switching from the cohort approach to the period approach. An estimate for the year 2014 based on a five-year period window from 2010–2014 would cause a drop in the trend curve since the five-year estimate is effected by survival experience from patients diagnosed several years ago. To avoid this, the time at risk is conditioned on the year of diagnosis. As an example, for the cohort of patients diagnosed in the period 2010–2014, complete five-year follow-up is available for patients diagnosed 2010–2013, whereas only four years of follow-up is available for patients diagnosed in 2014. To make up for this lack of follow-up, patients diagnosed

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before 2010 are considered at risk from January 1, 2014. This means that only the survival experience between year four and five for patients diagnosed in 2009 is used when estimating the five-year relative survival for the 2010–2014 cohort, making up for the last year of follow-up lacking for the 2014 patients.

All survival analyses were performed using the Stata (Stata/MP 16.0 Revision 16 Oct 2019) program `strs` (version 1.4.2.6).

2 References

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Statistics Norway, Statistics Norway provides statistics on population size each year, www.ssb.no/befolkning/statistikker/folkemengde.