Modeling The Probability Of Developing Cancer in Germany

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Abstract

Cancer in Germany is the second major cause of mortality after cardio-vascular diseases. The probability of developing cancer is an epidemiological measure that combines cancer mortality, non-cancer mortality and cancer incidence. Lifetime and age-conditional risk estimates of developing cancer for population in Germany are unknown. We show in this paper how to calculate the probability of developing cancer using the data on cancer incidence, cancer mortality and mortality from other causes, with the SAS-macro developed by Zdeb. Incidence estimates, cancer and non-cancer mortality and census data in Germany from 2000-2003 were used. A multiple decrement life table was derived by applying age-specific incidence estimates reported by Robert Koch Institute and mortality data from Federal Statistical Office to hypothetical cohorts of men and women. Our calculations showed an overall lifetime risk for developing cancer of 45.39% for a male, and 37.85% for a female newborns in Germany.

INTRODUCTION

Cancer is a major public health problem in Germany. The data on cancer incidence in Germany is collected by population-based cancer registries. Of sixteen federal states, ten (Baden-Wurttemberg, Bavaria, Bremen, Hamburg, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saarland, and Schleswig-Holstein) have separate population-based registries. Six others - Berlin, Brandenburg, Mecklenburg-West Pomerania, Saxony, Saxony-Anhalt and Thuringia have a common cancer registry, which is located in city of Berlin. Generally, it takes about two years to completely collect all necessary data on cancer incidence. After the data for a given year has been collected, all cancer documentation is sent to the Main Cancer Registry. The National German Children's Cancer Registry collects data on cancer in children under 15 in all sixteen federal states.[1] Department of Epidemiology and Health Reporting of Robert Koch Institute (RKI) incorporates the Main Cancer Registry; it processes and analyses data received from cancer registries and publishes annual reports based on received information.

Cancer mortality data is based on death certificates submitted by law to Federal Statistical Office of Germany. In 2003, one in four deaths in Germany (21.5 % of deaths among women and 27.9 % of deaths among men) was due to cancer, ranking second only to heart disease.[2] The most commonly causes of death from cancer among women were cancers of breast, lung and bronchus, colon, pancreas, and ovaries, accounting for approximately 52% of deaths from cancer among women.[2] In men, lung and bronchus, prostate, colon, and stomach were the most common fatal cancers, accounting for approximately one-half of the total cancer deaths among men.[2] Age-adjusted incidence rate of cancer is one of the mostly used statistics in describing cancer epidemiology. However, it is difficult to relate that statistic to an individual risk.[3] An average person who lives in Germany may want to know what his risks are to develop a cancer during his/her lifetime or at certain age. The simple question that an average 50-year old German might ask his physician would be “Will I get cancer in the next 15 years given that I have not got it till now?” What is a lifetime risk of getting cancer for an average 30 year-old woman? Such questions can not be answered without calculation of probabilities of cancer, which are averaged for the whole population. An individual risk to develop a cancer may be higher or lower, depending on the number of factors, such as smoking history, exposure to radiation, and other known and unknown factors.

OBJECTIVES

The probability of developing cancer or age-conditional risk

of developing cancer is an important measure that combines incidence of cancer, cancer mortality and non-cancer mortality.[4] Death from causes other than cancer is a competing risk for cancer incidence[4], and we have to take it into account when chance of developing cancer within a given age interval is calculated. Data on probabilities of developing cancer in Germany currently is not a part of yearly reports of cancer registries, so our primary objective is to show all those who work with cancer registry data in Germany, how easily these measures for specific types of cancer or for cancer in general can be modeled in SAS. We calculate and plot the cancer probabilities separately for male and female population using the data on cancer incidence from RKI, cancer and non-cancer mortality data and census data from the Federal Statistical Office of Germany from 2000-2003.

METHODS

General methodology to calculate the probability of developing cancer has been previously published by Goldberg et al. in 1956[5] and Zdeb in 1977[4]. In addition, in mid-90s Zdeb has developed very useful program to calculate and plot the cancer probabilities using SAS® and SAS/GRAPH® software.[6] This program allows calculating the probabilities for any specified cancer; our results are based on probability of cancer regardless of its type.

At first, number of population according to census and deaths from all causes in a given calendar year are used to construct a life table, which starts with a hypothetical population of 100,000. Then, the data on age-specific mortality of a given population is used to compute the proportion of people dying in each given 5-age interval up to age 94 and a 95+ interval. In the next step, two important estimates: 1) the number of hypothetical population –free from cancer and alive at the start of each interval and 2) new cancer cases occurring during each interval are calculated.[5] Number of people in the hypothetical population during each 5-age interval is decreased when someone from that population is being diagnosed with cancer for the first time in his life or dies from causes other than cancer.[5] Probability of developing a cancer during a certain interval is conditional on not having experienced a death prior to that interval, in other words, non-cancer death is a competing risk for cancer incidence.

The probability of developing cancer can therefore be easily calculated if age-specific mortality from all causes, age-specific mortality from cancer, age-specific incidence of cancer and number of population according to census for a given year are available.[6]

The incidence estimates from Main Cancer Registry are available only up to age 85+, the mortality rates from the Federal Statistical Office are available up to age 90+. To include age groups 85-89 and 90+, incidences for these two groups were obtained from incidence for age 85+. We based our decision to produce an estimate in this manner because the sensitivity of lifetime risk estimates to changes in incidence for people over 85 is likely to be small, as suggested by Feuer at al.[7] The latest estimates of cancer incidence (by November 2005) reported by Main Cancer Registry were calculated for 2000. If we look at the trend in estimated incidence of cancer country-wide among men and women between 1996 and 2000, we see no changes in incidence.[8] Therefore, our assumption was that this trend was going to remain stabilized through 2002. The calculations of probability estimates were performed for men and women separately using the data on mortality in year 2003, and estimates on cancer incidence for 2000, assuming that incidence in 2003 did not change much from estimates done for 2000. All calculations and plotting of cancer probabilities were done in SAS Version 8.2 by using a SAS-macro developed by Zdeb.[6]

RESULTS

An intermediate step in the program for calculating the probability estimates is calculation of life expectancies, according to that, females have higher life expectancy estimate at birth (81 years) compared to that for males (76 years). In calculation of probability of developing a cancer we assume a life that is extending 90 years. Table 1 shows the results of calculations of estimates of new cancer cases for cancer-free population at start of each 5-age interval occurring during given age interval, separately for men and women (column three and six, respectively).

Figure 1

Table 1: Newly diagnosed cancer cases and number of deaths from causes other than cancer in Germany, by sex.

	at beginning of interval	in the interval	causes in the interval*	at beginning of interval	in the interval	causes in the interval*
0-4	100000	119	523	100000	100	418
5-9	99358	65	50	99482	50	39
10-14	99243	59	60	99393	55	40
15-19	99124	124	246	99298	50	100
20-24	98754	163	350	99148	129	115
25-29	98241	148	344	98904	198	113
30-34	97749	284	362	98593	366	136
35-39	97103	537	524	98091	790	201
40-44	96042	726	846	97100	1278	316
45-49	94470	1191	1311	95506	1463	480
50-54	91968	1744	1774	93563	2408	682
55-59	88450	3474	2358	90473	3308	936
60-64	82618	5085	3302	86229	3450	1357
65-69	74231	6599	4865	81422	4192	2327
70-74	62767	7737	7074	74903	4926	4470
75-79	47956	6959	8677	65507	5404	7709
80-84	32320	6305	9299	52394	5380	11892
85-89	16716	3150	6998	35122	3217	14443
90+	6568	924	5644	17462	1086	16376

* Among cancer-free population at beginning of the interval provided they did not develop cancer during the interval

These numbers, initially low, gradually rise through middle age up to age 70 in men and 75 in women before decreasing. The total number of cancer-free population decreases due to cancer cases and deaths from causes other than cancer, as shown, during each interval both in men and women (column two and five, respectively). However, in men the number of cancer-free population is decreasing faster compared to that in women. Thus, at beginning of age 70 there are 74,903 women vs. 62,767 men that remained alive and free from cancer from initial number of 100,000.

The probability at birth of men and women developing cancer before a specified age (Z), given that they are cancer free prior to current age (Y) are shown in Tables 2 and 3.

Figure 2

Table 2: Percent developing cancer before a specified age (Z) provided they have never had cancer at current age (Y) in Germany, men.

Current age (Y), y	Develop Cancer by Age (Z), %																	
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	90+
0	0.10	0.15	0.20	0.25	0.38	0.58	0.95	1.74	3.01	4.48	6.88	10.19	13.64	17.84	22.76	28.17	33.55	36.76	37.85
5		0.05	0.10	0.15	0.28	0.48	0.85	1.65	2.93	4.40	6.82	10.15	13.61	17.83	22.78	28.21	33.62	36.85	37.95
10			0.05	0.10	0.23	0.43	0.80	1.60	2.88	4.35	6.78	10.10	13.58	17.79	22.75	28.19	33.60	36.84	37.93
15				0.05	0.18	0.38	0.75	1.54	2.83	4.30	6.73	10.06	13.53	17.76	22.72	28.16	33.58	36.82	37.91
20					0.13	0.33	0.70	1.50	2.78	4.26	6.69	10.02	13.50	17.73	22.70	28.15	33.58	36.82	37.92
25						0.20	0.57	1.37	2.66	4.14	6.57	9.92	13.41	17.65	22.63	28.09	33.53	36.78	37.88
30							0.37	1.17	2.47	3.95	6.39	9.75	13.25	17.50	22.50	27.98	33.43	36.70	37.80
35								0.81	2.11	3.60	6.05	9.43	12.94	17.22	22.24	27.75	33.23	36.51	37.62
40									1.32	2.82	5.30	8.71	12.26	16.58	21.65	27.22	32.76	36.07	37.19
45										1.53	4.05	7.52	11.13	15.52	20.68	26.34	31.97	35.34	36.47
50											2.57	6.11	9.80	14.28	19.54	25.32	31.07	34.51	35.67
55												3.66	7.47	12.10	17.55	23.52	29.47	33.02	34.22
60													4.00	8.86	14.58	20.84	27.08	30.81	32.07
65														5.15	11.20	17.84	24.44	28.39	29.73
70															6.58	13.79	20.97	25.27	26.72
75																8.25	16.46	21.37	23.03
80																	10.27	16.41	18.48
85																		9.16	12.25
90+																			6.22

Figure 3

Table 3: Percent developing cancer before a specified age (Z) provided they have never had cancer at current age (Y) in Germany, women.

Current age (Y), y	Develop Cancer by Age (Z), %																	
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	90+
0	0.10	0.15	0.20	0.25	0.38	0.58	0.95	1.74	3.01	4.48	6.88	10.19	13.64	17.84	22.76	28.17	33.55	36.76	37.85
5		0.05	0.10	0.15	0.28	0.48	0.85	1.65	2.93	4.40	6.82	10.15	13.61	17.83	22.78	28.21	33.62	36.85	37.95
10			0.05	0.10	0.23	0.43	0.80	1.60	2.88	4.35	6.78	10.10	13.58	17.79	22.75	28.19	33.60	36.84	37.93
15				0.05	0.18	0.38	0.75	1.54	2.83	4.30	6.73	10.06	13.53	17.76	22.72	28.16	33.58	36.82	37.91
20					0.13	0.33	0.70	1.50	2.78	4.26	6.69	10.02	13.50	17.73	22.70	28.15	33.58	36.82	37.92
25						0.20	0.57	1.37	2.66	4.14	6.57	9.92	13.41	17.65	22.63	28.09	33.53	36.78	37.88
30							0.37	1.17	2.47	3.95	6.39	9.75	13.25	17.50	22.50	27.98	33.43	36.70	37.80
35								0.81	2.11	3.60	6.05	9.43	12.94	17.22	22.24	27.75	33.23	36.51	37.62
40									1.32	2.82	5.30	8.71	12.26	16.58	21.65	27.22	32.76	36.07	37.19
45										1.53	4.05	7.52	11.13	15.52	20.68	26.34	31.97	35.34	36.47
50											2.57	6.11	9.80	14.28	19.54	25.32	31.07	34.51	35.67
55												3.66	7.47	12.10	17.55	23.52	29.47	33.02	34.22
60													4.00	8.86	14.58	20.84	27.08	30.81	32.07
65														5.15	11.20	17.84	24.44	28.39	29.73
70															6.58	13.79	20.97	25.27	26.72
75																8.25	16.46	21.37	23.03
80																	10.27	16.41	18.48
85																		9.16	12.25
90+																			6.22

The probability at birth of developing cancer during the lifetime is 45.39% for a male, and 37.85% for a female. The probability at birth to develop a cancer by age 55 drops for both sexes; 5.16% for a male, and 6.88% for a female, having by age 35 values slightly less than 1 percent in each sex category. We have plotted these probabilities (see Figure 1), because in this way age-conditional risks in males and females or sex-specific probabilities calculated during two different time periods are easy to compare than the numbers shown in Tables 2 and 3.

DISCUSSION

We used the data on cancer incidence and mortality in Germany to estimate the probabilities to develop cancer in lifetime or during specific time periods. The incidence data come from the Main Cancer Registry of Robert Koch Institute[8], and mortality and census data from the Federal Statistical Office of Germany.[2] The methodology for calculating the risk of average person of developing cancer has been introduced about half a century ago and since then has been further developed. [3,4,5,6,7] However, age-specific and lifetime risk probabilities of cancer are not routinely reported by health authorities in Germany. We would like to stress the importance of reporting of lifetime or age-specific risks to develop cancer and to remind all health care professionals about possibility to calculate in SAS these measures for specific types of cancer or for cancer regardless of its type. We calculated and plotted the probabilities of developing cancer for various start/end age combinations, by sex. We found, that the lifetime probability of developing cancer is higher for men (45.39%) than for women (37.85%). A small difference between risks of developing cancer before the age of 15 between boys (0.24%) and girls (0.20%), and poorer risks of males before the age of 30 in general are observed. In other words, one of about 400 boys

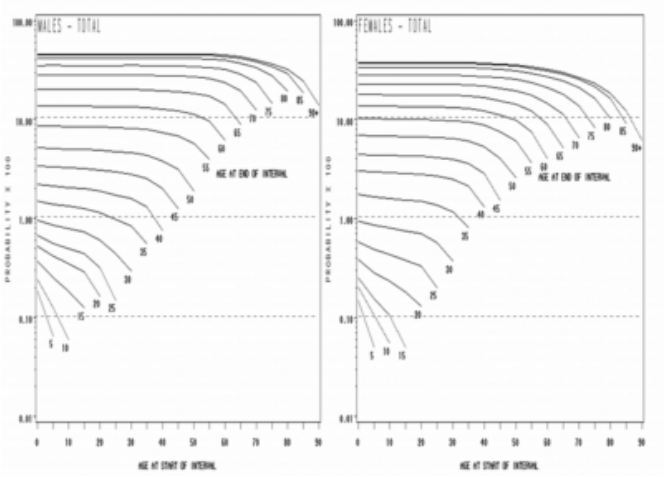
and one of 500 girls is likely to develop a cancer before his/her 15th birthday. The incidence estimates of all cancer in childhood in 1998-2002 from the National German Children's Cancer Registry also reveal the differences by gender, with rates being higher for boys than for girls.[8] There are some limitations in our estimates regarding the probability of cancer in Germany. First, our calculations were based on mortality data for 2003 and incidence estimates for 2000, which we assumed did not change till 2003 based on trend from 1994 till 2000 reported by RKI.[8] Second limitation is that behind the term "developing of cancer" is actually the "diagnosis of cancer", which takes into account only cases of cancer that have been diagnosed and not undiagnosed ones. So, we might actually underestimate the real probabilities of developing cancer. Third one, lifetime risk of cancer is an estimate for an average newborn in 2003 over his entire life. If factors that are responsible for cancer incidence in the current population in Germany will change as that baby ages, our projections for very long time periods are likely to become incorrect.

CONCLUSIONS

We conclude, that each second male and each third female born in Germany is likely to develop a cancer at some time during the life. However, women have slightly higher probability of developing cancer before the age of 60 (10.19%) than men (8.63%), probably because of the early age of onset of breast cancer, timely diagnosed due to frequent mammography screening.

Figure 4

Figure 1: Probability of developing cancer in Germany for various start/end age combinations, by sex.



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