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Epidemiology and Population Studies: SEER Series

Cancer Statistics, Trends, and Multiple Primary Cancer Analyses from the Surveillance, Epidemiology, and End Results (SEER) Program

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Key Words. Cancer statistics • Incidence • Lifetime risk • Multiple primaries • Survival • SEER

LEARNING OBJECTIVES

After completing this course, the reader will be able to:

1. Discuss the evolving changes in the following cancer-related measures: median age at diagnosis, incidence rate, death rate, lifetime risk, survival, and prevalence.
2. Explain important concepts affecting occurrence of multiple primary cancers at various cancer sites.
3. Describe the impact of the growing and aging population on the future number of cancer cases by age at diagnosis.

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ABSTRACT

An overview of cancer statistics and trends for selected cancers and all sites combined are given based on data from the Surveillance, Epidemiology, and End Results Program. Median age at diagnosis for all sites combined shows a 2-year increase from 1974 through 1978 to 1999 through 2003. Changes in cancer incidence rates from 1975 through 2003 are summarized by annual percent change for time periods determined by joinpoint regression analysis. After initial stability (1975–1979), incidence rates in women for all cancer sites combined increased from 1979 through 2003, although the rate of increase has recently slowed. For men, initial increases in all cancer sites combined (1975–1992) are followed by decreasing incidence rates (1992–1995) and stable trends from 1995 through 2003. Female thyroid cancer shows continued increasing incidence rates from 1981 through 2003. Blacks have the highest incidence and mortality rates for men and women for all cancer sites combined. Based on 2001 through 2003 data, the likelihood of developing cancer during one's lifetime is approximately one in two for men and one in three for women. Five-year relative survival for all stages combined (1996–2002) ranges from 16% for lung to 100% for prostate cancer patients. Cancer survival varies by stage of disease and race, with lower survival in blacks compared with whites. The risk of developing subsequent multiple primary cancers varies from 1% for an initial liver primary diagnosis to 16% for initial bladder cancer primaries. The impact on the future U.S. cancer burden is estimated based on the growing and aging U.S. population. The number of new cancer patients is expected to more than double from 1.36 million in 2000 to almost 3.0 million in 2050. ***The Oncologist*** 2007;12:20–37

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Introduction

This study provides an overview of statistics and trends for commonly occurring cancer sites. Data from the National Cancer Institute's (NCI's) Surveillance, Epidemiology, and End Results (SEER) Program database are used to estimate several cancer statistics, including median age at cancer diagnosis, incidence rates, death rates, lifetime risk of developing cancer, survival, and prevalence. Results are presented for these statistics as well as statistics on second or multiple cancers occurring among survivors previously diagnosed with cancer and estimates of the future national burden due to the changing age structure of the U.S. population.

Trends in population-based cancer rates may be studied by (a) using a comparison of aggregate data for discontinuous time intervals as a snapshot of the U.S. cancer burden or (b) examining yearly rates over a complete time range through modeling or more sophisticated analytical techniques to characterize national trends. Both approaches are used here, with a comparison of conclusions. Past trends in cancer incidence rates, coupled with shifts in the U.S. age structure, are described by changes in the median age of patients diagnosed, which is a summary statistic of age-specific incidence for the population at risk.

The risk of developing cancer during a person's lifetime and for a fixed period of time starting at selected ages comprises a strategic concept that can affect individual health behavior and medical management of patients undergoing routine clinical care. However, once diagnosed with cancer, prognosis is key with survival influenced by the type of cancer, the extent of disease, and treatment modalities. Improvements in detecting cancer at earlier stages and advances in treatment have yielded an increase in the population of living individuals ever diagnosed with cancer. In addition, with improved outcomes and greater life expectancy, there is an increasing need to consider the development of multiple primary cancers. Long-term high-quality population-based cancer registries such as SEER provide important information on individuals who develop more than one primary cancer during their lifetime.

Projections of the U.S. cancer burden are calculated for 2000 through 2050 and demonstrate that long-term shifts in the age composition of the population will lead to changes in the number of cancer cases diagnosed in various age groups, assuming there are no changes in cancer incidence rates. This growth in the number of future cancer cases affects demands placed on the U.S. health care delivery system.

Materials and Methods

The statistics presented herein, with the exception of mortality, were obtained from data collected at population-based registries that participate in NCI's SEER Program [1]. The SEER Program is the only comprehensive source of population-based data in the U.S. that includes stage of cancer at the time of diagnosis and follow-up of all patients for survival data. In addition, each registry collects data on patient demographics, primary tumor site and histology, and first course of treatment. Cancer cases are identified through records from hospitals, private laboratories, radiotherapy units, nursing homes, and other health service units in the registry's defined geographic area, as well as death certificates on which cancer is listed as a cause of death. Table 1 presents the central cancer registries that contribute data to the SEER Program, the diagnosis years of participation, the current population size (percentage) of the U.S. population included in SEER geographic regions, and the number of cancer cases diagnosed for 2003. By 1975, all SEER-9 registries were reporting data annually to NCI, and most recent reports for cancer trends are based on diagnosis years 1975–2003.

Cancers are coded according to the International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) [2]. Cases collected before 2001 were machine-converted to ICD-O-3 codes. Extent of disease was converted into the American Joint Committee on Cancer tumor, node, and metastasis staging categories [3].

The incidence and death rates presented in this article are expressed as the number of new primary cancers and deaths, respectively, per 100,000 persons at risk per year. Numerators (cases) for incidence rates are derived from the SEER Program, and numerators for death rates are obtained from the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention [4], which collects data from all state vital health reporting systems. For cancer sites that pertain to one sex only, the population at risk is the sex-specific population (e.g., females for ovarian cancer). Incidence and death rates are age-adjusted according to the 2000 U.S. standard population based on 5-year age groups [5]. Population estimates in the denominator for calculation of incidence and death rates are obtained from the U.S. Census Bureau [6].

SEER incidence and U.S. mortality data are available through 2003 diagnoses and deaths, respectively. When SEER cases are reported to NCI in November of each year, data are approximately 98% complete for all cancer sites combined, although some cancer sites, such as melanoma, are less complete. Cancer registries continuously update

Table 1. Central cancer registries contributing to the SEER Program

Database	Diagnosis years	SEER registries (geographic areas)	U.S. population covered (%)	Number of cases for 2003 (in situ and invasive)
SEER-9	1973–2003	Atlanta (1975), Connecticut, Detroit, Hawaii, Iowa, New Mexico, San Francisco/Oakland, Seattle/Puget Sound (1974), and Utah	10	134,434
SEER-13	1992–2003	SEER-9 plus Los Angeles, San Jose/Monterey, rural Georgia, and Alaska Natives in Alaska	14	183,043
SEER-17	2000–2003	SEER-13 plus Greater California, Kentucky, Louisiana, and New Jersey	26	357,460

California, Kentucky, Louisiana, and New Jersey receive federal funds from the Centers for Disease Control and Prevention (CDC) National Program of Cancer Registries (NPCR). National Cancer Institute (NCI) SEER funds are used to meet more stringent requirements of the SEER Program regarding completeness of case ascertainment, timeliness, quality metrics for data items, and follow-up. Greater California represents 53% of the state population. State registries for Georgia, Michigan, Washington, and Alaska receive federal funds from CDC NPCR. NCI SEER funds provide complete coverage for metropolitan regions and special populations whose data are reported to the respective state registries (percentage of state population): Atlanta and rural Georgia (37%); metropolitan Detroit (41%); Seattle/Puget Sound (69%); Greater Bay (San Francisco/Oakland and San Jose/Monterey) (19%); and Los Angeles County (28%).
Abbreviation: SEER, Surveillance, Epidemiology, and End Results.

their databases, and SEER uses statistical modeling to adjust the observed data for underestimation due to reporting delays estimated from the receipt of data files in subsequent years [7]. Incidence, mortality, and survival statistics are presented for four racial groups (white, black, Asian Pacific Islander, and American Indian/Alaska Native) and one ethnic group (Hispanic).

Trends over a given time interval are summarized with the annual percent change (APC) [5]. The APC is obtained by fitting a regression line through the logarithms of the rates for the given time period using weighted least squares. The slope of the line is tested for significant increases or decreases. In addition, the joinpoint regression model [8] is used to characterize changes in cancer rates over time. Each joinpoint denotes a statistically significant change in trend. For the joinpoint analysis, the overall significance level was set to $p = .05$, and a maximum of three joinpoints and four line segments were allowed.

The SEER software package DevCan was used to calculate the lifetime risk of developing cancer based on age-specific cancer rates for 2001–2003 diagnoses [9–12] from SEER-17 incidence cases. These rates are converted to the probabilities of developing cancer for a hypothetical population [5].

Cancer survival is estimated in different ways, depending on the intended purpose. Relative survival is calculated by comparing observed survival with expected survival from a set of people with the same characteristics as the patient cohort with respect to age, race, sex, and calendar period [13]. Relative survival estimates the effect of the cancer being considered on survival in the absence of other causes of death. It is always larger than or equal to the observed survival.

Multiple primaries describe diagnosis of two or more independent primary reportable neoplasms [14] in an individual. The number of multiple primary cancers observed in the follow-up period after diagnosis of a first primary cancer was divided by the expected number of cancers to produce a standardized incidence ratio (SIR) [15]. The expected number was obtained by applying age-, sex-, and site-specific incidence rates by calendar year to person-years at risk for each respective cancer case. The analysis cohort included patients from SEER-9 areas who were diagnosed from 1973 through 2003 with 18 common cancers for men and women. Excluded from the analyses were all death certificate-only, autopsy, and individual cases with in situ disease as the first cancer diagnosis. Follow-up times, that is, person-years, were computed from 2 months after diagnosis to avoid counting simultaneous cancers and were censored at the time of death, date last known alive, or December 31, 2003, whichever came first.

The number of new cancer cases by sex for selected cancer sites is projected into the future using age-specific population projections, with a baseline assumption that cancer rates remain at their current level. Population estimates for single-year ages were obtained from the U.S. Census Bureau for the years 2000, 2010, 2020, 2030, 2040, and 2050 [16, 17]. The single-year age- and sex-specific estimated cancer counts were calculated using delay-adjusted incidence rates obtained by applying appropriate delay-adjustment ratios from SEER-9 to the SEER-17 data. Estimated single-year counts were then produced for each type of can-

cer for diagnosis years 1998 through 2002 and summed to calculate average single-year age-specific incidence rates. The single-year age-specific incidence rates for 1998–2002 were applied to the U.S. Census Bureau population estimates to project total cancer case counts. Counts for all sites combined, colon and rectum, and lung and bronchus cancers were estimated for both sexes. Counts for breast cancer and all sites for women and counts for prostate cancer and all sites for men were based on sex- and site-specific incidence rates. The cancer case counts were summed into four age groups: less than 45 years, 45–64 years, 65–84 years, and 85 years and older.

Complete prevalence is the number of people in a population who are alive on a certain date and who have been diagnosed with cancer at any time in their lives [5]. It differs from incidence in that it considers both newly diagnosed and previously diagnosed persons. Prevalence is a function of both the incidence of the disease and survival.

Results

The American Cancer Society has estimated, based on SEER Program data and NCHS reported deaths, that approximately 1,399,790 people will be diagnosed with cancer and 564,830 will die of this disease in 2006 [18]. An estimated 14,357 new cases of childhood cancers and 2,394 deaths are expected among those under the age of 20. Although childhood cancers are relatively rare, cancer is the leading cause of death in this age group. Death rates for childhood cancer have declined by approximately 47% since 1975. Rates for childhood cancers vary greatly by age. Unlike adult cancers, pediatric and adolescent cancers often are best described by a combination of histological type and primary site [19]. For this reason, childhood cancers are not further discussed in detail here.

Table 2 shows the distribution of median age at diagnosis for selected primary cancer sites by 5-year time periods from 1974 through 2003. Comparing the most recent 5-year period (1999–2003) with the earliest period (1974–1978), median age at cancer diagnosis for all sites combined increased by 2 years. Of 44 individual cancer sites, 19 sites (43%) showed an increase in median age at diagnosis of more than 2 years, and five sites (11%) showed a decrease in median age at diagnosis of more than 2 years.

Mesotheliomas showed the largest increase in median age at diagnosis (11 years). Cancer of bones and joints, Hodgkin lymphoma, cancer of the lip, lung and bronchus, and melanoma of the skin showed an increase in median age at diagnosis of 5 or more years. The following cancers were diagnosed at especially young ages (median age of 38 or younger): cancers of the bones and joints, Hodgkin lymphoma, and cancer of the testis. For these cancers, median age at diagnosis increased by 3–8 years between the 1974–1978 and 1999–2003 time periods. For acute lymphocytic leukemia, primarily a pediatric cancer, the age at diagnosis increased by 3 years.

Cancers of the cervix uteri, anus, anal canal and anorectum, pleura, and prostate showed a decrease in median age at diagnosis of 4 or more years between the 1974–1978 and 1999–2003 time periods. Kaposi sarcoma showed a dramatic 33-year decrease in median age at diagnosis. Until the early 1980s, Kaposi sarcoma was a rare disease found mainly in older men. During the last 20 years, most cases developed in association with human immunodeficiency virus infection and AIDS. The median age at diagnosis during the time period 1974–1978 was 74 years, compared with a median age at diagnosis of 41 years during the time period 1999–2003.

Age-adjusted incidence rates are shown in Table 3 for 20 cancer types by sex and selected discontinuous 5-year time periods from 1974 to 2003. The description of data in this table is supplemented with conclusions drawn from an examination of yearly data adjusted for reporting delay [7] using joinpoint regression models [8]. Figures 1A and 1B demonstrate the results of the joinpoint regression analysis (i.e., show the years in which rates changed significantly) for the top 10 cancer sites in men and in women. Each bar is divided into the portions of the interval 1975 through 2003 with a change in rates—intervals are color-coded, with red denoting periods with increasing trends, green for decreasing trends, and yellow for periods with stable trends. The significant APCs for each time period are shown within the bar or for the most recent period at the right border of the bar. Joinpoint analysis can be used to quantify changes in incidence rates for specific years, as well as calculate statistically significant trends in time. This method of analyzing the data shows a continuum of change, whereas comparisons of isolated time intervals do not always capture the nature of change over the intervening period.

Table 3 shows an increase in the incidence of breast cancer from 1974 to 2003. A more detailed analysis (Fig. 1B) of yearly data indicates a marked increase from 1980 to 1987 (3.7% per year) followed by a lesser increase (0.5% per year) from 1987 through 2001, after which rates began to stabilize from 2001 through 2003. In this example, incidence rates shown in Table 3 present an incomplete picture of the long-term breast cancer trend. Thus, caution should be applied when considering statistics using discontinuous fixed intervals for assessing long-term trends and identifying years in which a change in trends has occurred.

For all sites combined, age-adjusted cancer incidence rates among men increased dramatically until 1992, fell sharply during the next few years, and since 1995 have been

Table 2. Median age at diagnosis for selected cancer sites, Surveillance, Epidemiology, and End Results (SEER) population-based cancer registries, 1974–2003

Cancer sites	1974–1978	1979–1983	1989–1993	1999–2003
All sites	65	66	68	67
Bones and joints	33	32	36	41
Brain and ONS	54	56	56	55
Breast	60	62	64	61
Cervix uteri	53	52	47	47
Colon and rectum	70	70	72	72
Anus, anal canal, and anorectum	64	66	66	60
Colon excluding rectum	70	71	72	73
Rectum and rectosigmoid junction	68	69	69	68
Corpus and uterus, NOS	61	64	66	63
Esophagus	65	65	68	69
Eye and orbit	59	60	61	59
Gallbladder	73	74	74	74
Hodgkin lymphoma	32	32	34	37
Kaposi sarcoma	74	44	37	41
Kidney and renal pelvis	63	65	66	65
Larynx	62	63	65	64
Leukemia	66	66	68	68
Acute lymphocytic leukemia	9	11	11	12
Acute myeloid leukemia	64	65	67	68
Chronic lymphocytic leukemia	70	70	71	72
Liver and IBD	66	67	68	66
Lung and bronchus	64	66	68	70
Melanoma of the skin	51	52	55	57
Mesothelioma	63	67	70	74
Myeloma	68	69	70	71
Non-Hodgkin lymphoma	64	65	65	67
Nose, nasal cavity, and middle ear	62	64	64	64
Oral cavity and pharynx	62	63	64	62
Lip	65	66	68	70
Tongue	62	62	63	61
Ovary	60	62	65	63
Pancreas	69	70	72	72
Penis	66	66	68	70
Pleura	70	68	70	65
Prostate	73	72	71	68
Small intestine	65	65	68	67
Soft tissue including heart	55	55	57	56
Stomach	69	70	71	72
Testis	31	30	33	34
Thyroid	44	44	45	46
Ureter	70	71	73	74
Urinary bladder	69	69	71	73
Vagina	67	67	69	68
Vulva	68	70	71	70

Abbreviations: IBD, intrahepatic bile duct; NOS, not otherwise specified; ONS, other nervous system.
Source: National Cancer Institute's SEER Program (SEER-9 areas); data from the Atlanta registry were available for cases diagnosed from 1975 and later.

Table 3. Average annual age-adjusted cancer incidence rates for selected cancer sites by sex, Surveillance, Epidemiology, and End Results (SEER) Program, 1974–2003

	Diagnosis years: males and females				Diagnosis years: males				Diagnosis years: females			
Cancer sites	**1974–1978**	**1979–1983**	**1989–1993**	**1999–2003**	**1974–1978**	**1979–1983**	**1989–1993**	**1999–2003**	**1974–1978**	**1979–1983**	**1989–1993**	**1999–2003**
All sites	404.6	422.3	490.8	478.1	476.5	508.9	615.1	565.2	365.8	373.5	412.5	418.4
Bones and joints	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	0.7	0.7	0.8	0.8
Brain and ONS	5.8	6.3	6.9	6.6	7.0	7.7	8.4	7.9	4.8	5.2	5.7	5.5
Breast									104.1	105.7	130.6	134.1
Cervix uteri									13.9	11.4	10.2	7.6
Colon and rectum	61.0	63.3	59.2	52.8	71.3	75.1	72.1	61.9	54.0	55.5	50.2	45.7
Corpus and uterus, NOS									33.1	27.2	24.6	24.7
Hodgkin lymphoma	14.2	16.1	21.4	22.4	16.7	19.1	26.4	27.0	12.2	13.8	17.2	18.7
Kidney and renal pelvis	7.6	8.3	10.6	12.4	11.1	12.2	14.8	17.1	5.0	5.4	7.3	8.6
Leukemia	13.0	12.8	13.0	12.5	17.2	17.4	17.1	16.4	10.0	9.8	10.0	9.6
Liver and IBD	2.7	2.8	4.1	5.7	4.0	4.3	6.3	8.7	1.7	1.7	2.4	3.2
Lung and bronchus	54.7	61.6	68.4	63.8	92.7	99.1	96.6	80.9	26.6	34.7	48.5	51.6
Melanoma of the skin	8.2	10.7	14.3	18.7	8.8	11.9	17.4	23.3	7.8	9.9	12.1	15.5
Non-Hodgkin lymphoma	11.2	13.2	18.4	18.8	13.1	15.5	23.0	23.0	9.7	11.5	14.6	15.6
Oral cavity and pharynx	0.4	0.4	0.4	0.3	0.6	0.7	0.7	0.4	0.2	0.3	0.2	0.1
Ovary									16.0	15.6	15.3	13.9
Pancreas	11.7	11.7	11.3	11.3	14.7	14.1	12.9	12.8	9.5	10.0	10.1	10.0
Prostate					96.1	107.6	195.8	177.8				
Stomach	11.9	11.2	9.4	8.0	17.2	16.6	14.0	11.3	8.1	7.5	6.2	5.4
Thyroid	5.0	4.5	5.6	8.3	3.1	2.7	3.2	4.3	6.7	6.2	7.8	12.2
Urinary bladder	19.5	20.2	21.1	21.3	34.4	36.1	37.5	37.5	9.1	9.3	9.6	9.6

Incidence rates are per 100,000 population and are age-adjusted to the 2000 U.S. standard million population by 5-year age groups.
Abbreviations: IBD, intrahepatic bile duct; NOS, not otherwise specified; ONS, other nervous system.
Source: National Cancer Institute's SEER Program (SEER-9 areas); data from the Atlanta registry were available for cases diagnosed from 1975 and later.

stable (Fig. 1A). Among women, however, the cancer incidence rates continued to rise during the period from 1979 to 2003, although the rate of increase diminished after 1987. Incidence rates for leukemia, lung cancer, melanoma, non-Hodgkin lymphoma, and thyroid cancer in women showed an increase during 1975–2003 (Fig. 1B). The analysis for leukemia presented in Table 3 does not convey this long-term increase since adjustment for reporting delay is included in Figures 1A and 1B but not in Table 3 [20]. Delay-adjusted incidence rates include estimates for cancers reported after the initial data collection period for a diagnosis year. Incidence of thyroid cancer began to increase sharply in women early in the 1980s (Table 3; Fig. 1B), and long-term increases in incidence rates have occurred for cancer of the liver and kidney and renal pelvis, as well as Hodgkin lymphoma. Ovarian cancer incidence rates began to decline in 1985 and continued to decline through 2003 (Fig. 1B).

Among men, incidence rates increased (Fig. 1A) during this entire period for cancers of the kidney and renal pelvis, leukemia, and melanoma (which began to stabilize in 2001), but decreased for cancers of the oral cavity and pharynx and for the lung (beginning in 1982). The long-term trends for prostate cancer seem to fluctuate from 1975 to 2003 (Fig. 1A), increasing significantly since the late 1980s and early 1990s (Fig. 1A; Table 3). A sharp decline (Fig. 1A) in prostate cancer incidence occurred between 1992 and 1995, followed by a modest increase in the most recent segment from 1995 to 2003. Increasing trends of liver cancer are at least twice as high in men as in women, whereas the thyroid cancer incidence rate in men is approximately half that observed in women.

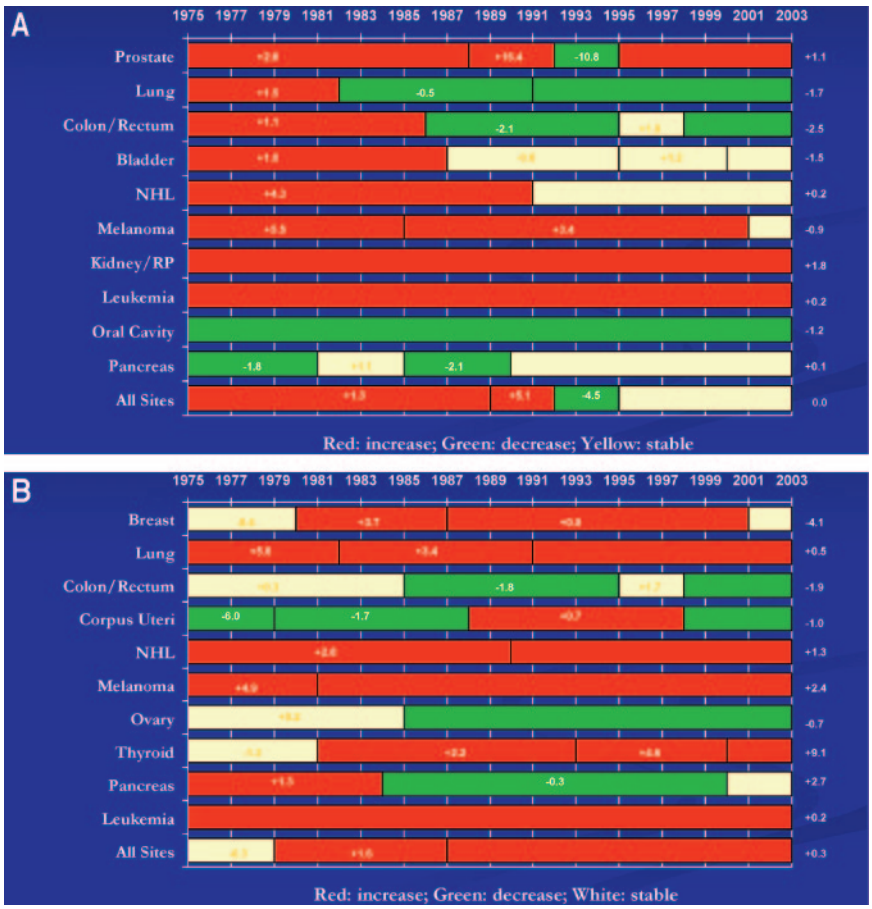

Figure 1. Cancer incidence trends (1975–2003) for top 10 sites, Surveillance, Epidemiology, and End Results Program (SEER-9 areas; joinpoint analyses on delay-adjusted SEER-9 incidence rates with annual percent change). **(A):** Males. **(B):** Females. Abbreviations: NHL, Non-Hodgkin lymphoma; RP, renal pelvis.

Incidence rates by race and ethnic group based on SEER-17 areas are displayed in supplemental online Table A. Sites selected were the top cancers based on 2000–2003 age-adjusted incidence rates for all races combined for the given sex group (male, female, combined). Blacks had the highest incidence rate (504.4 per 100,000) for men and women for all sites combined. Prostate cancer incidence was 258.3 per 100,000 for black men and 163.4 per 100,000 for white men. Incidence rates for men with cancers of the prostate, lung and bronchus, colon and rectum, and oral cavity and pharynx were higher for blacks, whereas cancers of the urinary bladder, melanoma of the skin, and non-Hodgkin lymphoma had higher incidence rates for whites. American Indian/Alaska Native men had the highest incidence rate of kidney and renal pelvis cancer, at 20.9 per 100,000. Among women, incidence rates for cancers of the colon and rectum and of the pancreas were higher for blacks than whites. White women had the highest incidence rates for breast, lung and bronchus, corpus and uterus not otherwise specified (NOS), non-Hodgkin lymphoma, melanoma of the skin, ovary, and thyroid cancers.

Death rates by race and ethnicity are displayed in supplemental online Table B. The sites selected were the top cancers based on 2000–2003 age-adjusted death rates for all races combined for the given sex group (male, female, combined). Blacks had the highest death rates for men and women for all sites combined. Death rates for cancers of the lung and bronchus, prostate, colon and rectum, pancreas, and esophagus in men were highest in blacks. Leukemia, non-Hodgkin lymphoma, and urinary bladder death rates were highest for whites. Asian Pacific Islanders had the highest mortality for liver and intrahepatic bile duct cancer for both men and women (data not shown). Among women, overall death rates for cancers of the lung and bronchus and ovary, and for non-Hodgkin lymphoma and leukemia, were higher in whites than blacks, whereas female mortality for cancers of the breast, colon and rectum, pancreas, and corpus and uterus NOS were higher in blacks than in whites.

Table 4 displays the lifetime risk of developing cancer, assuming that a person is cancer-free at the starting age. Approximately 45% (one in two) men and 38% (one in three) women will be diagnosed with some form of invasive can-

Table 4. Lifetime risk of developing cancer based on age at diagnosis, Surveillance, Epidemiology, and End Results (SEER-17 areas), with rates for 2001–2003 diagnosis years

		Males and females			Males			Females		
Cancer sites	**Starting age**	**+10 years**	**+30 years**	**Even-tually**	**+10 years**	**+30 years**	**Even-tually**	**+10 years**	**+30 years**	**Even-tually**
All sites	0	1 in 612	1 in 134	1 in 2	1 in 580	1 in 140	1 in 2	1 in 650	1 in 128	1 in 3
	45	1 in 24	1 in 4	1 in 2	1 in 26	1 in 3	1 in 2	1 in 22	1 in 4	1 in 3
	65	1 in 6	1 in 3	1 in 3	1 in 5	1 in 2	1 in 2	1 in 8	1 in 3	1 in 3
Prostate	0	NA	NA	NA	—	—	1 in 6	NA	NA	NA
	45	NA	NA	NA	1 in 103	1 in 8	1 in 5	NA	NA	NA
	65	NA	NA	NA	1 in 11	1 in 6	1 in 6	NA	NA	NA
Breast	0	NA	NA	NA	NA	NA	NA	—	—	1 in 8
	45	NA	NA	NA	NA	NA	NA	1 in 49	1 in 12	1 in 8
	65	NA	NA	NA	NA	NA	NA	1 in 26	1 in 12	1 in 12
Lung and bronchus	0	—	—	1 in 14	—	—	1 in 12	—	—	1 in 16
	45	1 in 247	1 in 23	1 in 14	1 in 221	1 in 20	1 in 12	1 in 280	1 in 27	1 in 16
	65	1 in 34	1 in 16	1 in 16	1 in 28	1 in 13	1 in 13	1 in 41	1 in 19	1 in 19
Colon and rectum	0	—	—	1 in 18	—	—	1 in 17	—	—	1 in 19
	45	1 in 257	1 in 34	1 in 18	1 in 231	1 in 30	1 in 17	1 in 287	1 in 39	1 in 18
	65	1 in 53	1 in 20	1 in 20	1 in 44	1 in 19	1 in 18	1 in 63	1 in 21	1 in 21
Urinary bladder	0	—	—	1 in 43	—	—	1 in 28	—	—	1 in 87
	45	1 in 880	1 in 83	1 in 42	1 in 571	1 in 52	1 in 26	—	1 in 182	1 in 86
	65	1 in 119	1 in 46	1 in 45	1 in 71	1 in 28	1 in 27	1 in 272	1 in 98	1 in 95
Corpus and uterus, NOS	0	NA	NA	NA	NA	NA	NA	—	—	1 in 40
	45	NA	NA	NA	NA	NA	NA	1 in 305	1 in 57	1 in 41
	65	NA	NA	NA	NA	NA	NA	1 in 122	1 in 62	1 in 62
Non-Hodgkin lymphoma	0	—	—	1 in 51	—	—	1 in 47	—	—	1 in 55
	45	1 in 537	1 in 91	1 in 52	1 in 450	1 in 81	1 in 48	1 in 661	1 in 103	1 in 56
	65	1 in 157	1 in 64	1 in 63	1 in 137	1 in 59	1 in 58	1 in 178	1 in 70	1 in 68

Lifetime risk is conditional on being cancer-free at starting age. Sites selected are those with at least 1 in 50 (≥2%) lifetime risk of developing cancer. NA, not applicable.
—, risk is 1 in more than 1,000.
Abbreviation: NOS, not otherwise specified.
Source: National Cancer Institute's SEER Program (SEER-17 areas).

cer during their lifetime. For a person 45 years of age, the risk of developing cancer during the next 10 years is 1 in 24 (1 in 26 for men; 1 in 22 for women). One in six persons, aged 65 years, will be diagnosed with cancer by age 75 (one in five for men; one in eight for women). Men have a one in six risk of having prostate cancer during their lifetime, and one in eight women will develop breast cancer. The lifetime risk of developing lung and bronchus cancer is 1 in 12 for men and 1 in 16 for women. Childhood cancers are rare; the risk of a newborn child developing cancer by the age of 10 is 1 in 612. By 30 years of age, 1 in 134 persons will develop some form of cancer. Starting at 65 years of age, approximately 43% (one in two) men and 30% (one in three) women will develop cancer.

Five-year relative survival for selected sites is shown by stage at diagnosis, sex, and race in Table 5. The overall 5-year relative survival for individuals diagnosed in 1996–2002 from SEER-17 geographic areas was 89% for female breast, 65% for colon and rectum, and 16% for lung and bronchus. For prostate cancer, relative 5-year survival is

Table 5. Five-year relative survival for selected cancer sites by race, sex, and stage, Surveillance, Epidemiology, and End Results (SEER-17 areas), 1996–2002

	Stage					
Cancer sites	**All**	**I**	**II**	**III**	**IV**	**Unknown**
Males and females						
Colon and rectum						
All races	65%	95%	82%	61%	8%	64%
White	66%	95%	83%	62%	8%	65%
Black	56%	89%	74%	55%	6%	59%
Lung and bronchus						
All races	16%	59%	33%	10%	2%	17%
White	16%	59%	33%	10%	2%	17%
Black	13%	52%	29%	9%	2%	14%
Males						
Prostate						
All races	100%		100%[a]	99%	49%	98%
White	100%		100%[a]	100%	50%	99%
Black	96%		100%[a]	95%	45%	93%
Colon and rectum						
All races	66%	96%	83%	62%	8%	68%
White	67%	97%	84%	63%	8%	68%
Black	57%	88%	77%	57%	6%	63%
Lung and bronchus						
All races	14%	54%	32%	9%	2%	15%
White	14%	55%	32%	9%	2%	15%
Black	11%	47%	27%	7%	2%	14%
Females						
Breast						
All races	89%	100%	89%	60%	21%	83%
White	90%	100%	90%	62%	23%	84%
Black	78%	99%	82%	45%	12%	71%
Colon and rectum						
All races	64%	94%	82%	61%	8%	61%
White	65%	94%	82%	61%	8%	62%
Black	55%	90%	72%	54%	6%	55%
Lung and bronchus						
All races	19%	63%	35%	11%	3%	19%
White	19%	63%	35%	11%	3%	19%
Black	15%	57%	31%	11%	2%	15%

Rates are based on SEER-17 areas, Greater California. Kentucky, Louisiana, and New Jersey contributed cases for diagnosis years 2000–2002. The remaining 13 SEER areas contributed cases for the entire period 1996–2002. Rates are based on follow-up of patients through 2003.
[a] For prostate, clinical stage was used and based on [3]; stages I and II were combined.
Source: National Cancer Institute's SEER Program (SEER-17 areas).

49% at stage IV, although at all stages it is 100%. This can happen because relative survival measures exceed mortality relative to the general population, calculated as a ratio of the observed and expected survival.

Survival changes considerably depending on stage at diagnosis. The 5-year relative survival varies from 95% to 98% for patients diagnosed with stage I to stage IV cancer of the colon and rectum, from 59% to 62% for patients with

stage I to stage IV lung and bronchus cancer, and from 100% to 149% for those with clinical stage I/II to clinical stage IV prostate cancer. For female breast cancer, the 5-year relative survival for diagnosis at early-stage is very good (100% for all races combined), but if metastatic disease is diagnosed (stage IV), survival drops to 21% for all races combined.

There is a difference in survival between men and women diagnosed with lung cancer. For persons diagnosed with stage I lung cancer, there is a nine-percentage-point higher relative 5-year survival for women compared with men. The sex difference is smaller for later-stage lung cancer but persists for both white and black patients.

For most cancers, relative survival generally is higher for white than for black patients. For female breast cancer, 5-year relative survival for all stages combined is 90% in white women compared with 78% in black women, with the highest difference occurring in stage III disease (5-year relative survival is 62% in whites vs. 45% in blacks). Similarly, there is a 10-percentage-point difference between races for patients diagnosed at all stages combined of colon and rectum cancer. This survival difference between white and black patients is the greatest for stage I disease in men and stage II disease in women, with smaller differences within other stages. Prostate cancer clinical stage IV survival is five percentage points higher in white males than in black males.

Tables 6, 7, and 8 relate to multiple primary cancers. Each table shows 18 primary sites at which cancer first originated. Table 6 shows the number of patients diagnosed with a first primary cancer, the number and percentage of these patients who then develop multiple primaries (within 2 months and after 2 months of an initial diagnosis), median age at diagnosis based on first cancer, and the 5-year relative and observed survival for these individuals with a first cancer diagnosis. Urinary bladder is the initial (or index) primary cancer site with the highest percentage of individuals with multiple primary cancers (16%), followed by oral cavity and pharynx (15%) and corpus and uterus (11%). When compared to all other primaries, liver cancer showed the fewest multiple primary occurrences (only 1%). As expected, there is an association between the risk of developing subsequent cancers and patient survival, with the exception of thyroid cancer.

SIRs [15] are shown in Table 7 for males and in Table 8 for females. The initial primaries shown are those with the largest number of multiple primary events. Reporting rules influence the occurrence of multiple primaries, particularly for same-site tumors and tumor pairs affected by treatment that removes the target organ.

Statistically elevated SIRs were found for several initial primary cancer sites. Urinary bladder cancer patients had an elevated risk of subsequent cancers of the kidney and other urinary organs (males: SIR = 11.08, $p < .05$; females: SIR = 17.79, $p < .05$). For cancers of the oral cavity and pharynx, the highest SIRs were found for multiple primaries of the same site in both sexes; in addition, there was an increased risk for cancer of the esophagus (males: SIR = 7.67, $p < .05$; females: SIR = 18.71, $p < .05$). Kidney and renal pelvis cancer patients had an elevated risk of multiple primary cancers at the same or proximal site, as well as in the bladder. Colon and rectum cancer patients had a significant incidence risk of subsequent cancer of the colon. The risk of melanoma as a multiple primary cancer was highest in melanoma patients, who also had an increased risk of a subsequent thyroid cancer.

The risk of multiple primary breast cancers (SIR = 1.55, $p < .05$) was significantly elevated in female breast cancer patients. An increased risk of subsequent thyroid cancers (SIR = 1.19, $p < .05$) was observed after an initial diagnosis of breast cancer. Hormonal factors have been suspected to be relevant to the etiology of thyroid cancer as well as breast cancer [21]. For a first cancer of the corpus and uterus, the risk of multiple primaries of the bladder and other urinary organ diseases was elevated (SIR = 1.41, $p < .05$). Incidence of thyroid cancer after prostate cancer diagnosis was noted in men (SIR = 1.20, $p < .05$).

Projections of cancer incidence counts for 2000–2050 are displayed in Table 9, and the pattern of estimated total number of cancers for age groups is presented in Figure 2. As baby boomers (persons born from 1946 to 1964) age and move into the 45–64-age bracket by 2010, more new cancers are expected in this age group if incidence rates remain the same or do not decrease. For example, the group of adults aged 45–64 in the male and female all sites combined category shows an increase from 32% in 2000 to 37% in 2010. A similar increase in this age group can be seen for all of the top cancer sites. By 2030, baby boomers will have aged to between 66 and 84 years, the high-risk age group for cancer. This population growth impact is seen in the increase in the number of cancer patients in the 65–84-year age group in the year 2030. This increase is consistent for all of the top cancer sites.

The estimate for the total U.S. population of the prevalence of individuals alive on January 1, 2003 who had a previous diagnosis of cancer at any time is about 10.5 million (Table 10). This estimate includes individuals who recently were diagnosed with cancer, those who have survived many years after diagnosis, those with active cancer, and those who are cancer-free. Cancer is more prevalent in women, with an estimated 5.8 million having had a diagnosis of cancer by 2003. Men over the age of 70 constitute more than

Table 6. Characteristics of most common initial (or index) primary cancer sites with subsequent multiple primaries, Surveillance, Epidemiology, and End Results (SEER-9 areas), 1973–2003

First primary cancer or index cancer		Multiple primary cancers		First primary cancer or index cancer		
					5-year survival	
Cancer sites	Count[a]	Counts within 2 months	Counts beyond 2 months (% of first primary)	Median age at diagnosis[b]	Relative (%)	Observed (%)
Brain and ONS	35,576	116	523 (2%)	55	32	29
Breast	370,513	6,467	37,760 (10%)	62	82	73
Cervix uteri	33,503	336	2,396 (7%)	48	70	65
Colon and rectum	287,072	9,451	29,274 (10%)	71	58	46
Corpus and uterus, NOS	84,140	1,256	8,926 (11%)	63	84	75
Esophagus	20,959	379	665 (3%)	66	11	9
Kidney and renal pelvis	49,632	1,096	5,154 (10%)	65	59	50
Leukemia	60,560	529	3,813 (6%)	67	48	40
Liver and other[c]	12,408	309	169 (1%)	69	10	9
Lung and other respiratory organs[d]	287,422	3,879	12,273 (4%)	67	14	11
Melanoma	78,863	718	8,119 (10%)	58	87	79
Myeloma	27,312	239	1,299 (5%)	70	30	24
Non-Hodgkin lymphoma	86,140	665	6,044 (7%)	65	56	48
Oral cavity and pharynx	65,210	1,338	9,697 (15%)	62	52	45
Ovary	42,330	1,019	2,076 (5%)	62	42	38
Prostate	347,068	3,209	30,682 (9%)	70	90	68
Thyroid	35,954	214	2,531 (7%)	45	96	92
Urinary bladder	106,581	2,677	16,642 (16%)	70	78	61

[a] Two-month latency period was used.
[b] Five-year relative and observed survival conditioning on cases surviving at least 3 months after diagnosis.
[c] Includes liver, gallbladder, intrahepatic bile duct, and other biliary.
[d] Includes lung, bronchus, trachea, mediastinum, and other respiratory organs.
Abbreviations: NOS, not otherwise specified; ONS, other nervous system.
Source: National Cancer Institute's SEER Program (SEER-9 areas).

half of all men diagnosed with cancer. More than a million women in the 50–69-year age group and another million women over the age of 70 have been diagnosed with breast cancer. Approximately 95% of the population previously diagnosed with acute lymphocytic leukemia is under the age of 50. The prevalence of prostate cancer is higher in men over the age of 70: nearly 1.3 of the 1.9 million men previously diagnosed with prostate cancer are at least 70 years old.

Discussion

This study presents current SEER data and discusses measures of cancer incidence, mortality, lifetime risk, survival, prevalence, multiple primaries, and future projections of the numbers of people expected to be diagnosed with cancer. The goal of the National Cancer Institute's SEER Program is to collect complete and accurate data on all cancers diagnosed among residents of geographic areas covered by SEER cancer registries, currently comprising 26% of the U.S. population. SEER data provide clinicians and researchers with the opportunity to explore cancer trends, identify changing patterns in the cancer burden across diverse U.S. populations, measure progress against cancer, and examine implications for cancer control in the context of associations with risk factors, prevention interventions, and the dissemination of advances in treatment. Unique features of the SEER Program provided by more than 30 years of high-quality data include the following: (a) near-universal completeness of cases, with at least 98% of all malignant and specific in situ cancers reported within 22 months of diagnosis; (b) a combination of passive and active approaches for follow-up of all patients to estimate survival and prognosis; (c) long-term, population-based national trends in incidence and survival by stage at diagnosis; (d) a

Table 7. Observed cases and SIR for multiple primaries following diagnosis of an initial or index primary cancer in males, Surveillance, Epidemiology, and End Results (SEER-9 areas), 1973–2003[a]

	First primary cancer or index cancer											
	Urinary bladder		Oral cavity and pharynx		Kidney and renal pelvis		Colon and rectum		Melanoma of skin		Prostate	
Multiple primary sites	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR
Brain and ONS	113	0.92	38	0.82	30	0.94	125	0.72[b]	59	1.07	489	1.02
Colon excluding rectum	1,249	0.99	457	1.09	320	1.11	2,837	1.49[b]	395	0.96	5,164	0.95[b]
Esophagus	168	0.98	482	7.67[b]	40	0.9	250	0.96	39	0.60[b]	633	0.83[b]
Eye and orbit	20	1.06	13	1.94[b]	4	0.87	27	1.02	9	1.14	75	1.03
Hodgkin lymphoma	32	1.21	18	1.65	5	0.69	38	0.99	9	0.64	88	0.89
Larynx	223	1.30[b]	262	3.84[b]	34	0.74	243	1.00	32	0.48[b]	579	0.84[b]
Leukemia	379	0.98	118	0.92	98	1.11	495	0.87[b]	131	0.97	1,523	0.94[b]
Liver and other[c]	219	1.06	132	1.81[b]	52	1.00	299	0.91	58	0.79	706	0.75[b]
Lung and other respiratory organs[d]	3,475	1.54[b]	2,283	2.84[b]	574	1.03	3,102	0.92[b]	567	0.71[b]	7,614	0.79[b]
Melanoma of the skin	296	0.85[b]	160	1.33[b]	105	1.20	451	0.95	1,437	8.45[b]	1,554	1.11[b]
Myeloma	149	0.88	45	0.78	49	1.19	229	0.89	59	1.00	781	1.00
Non-Hodgkin lymphoma	405	0.91	165	1.08	99	0.91	600	0.93	212	1.17[b]	1,880	1.00
Oral cavity and pharynx	319	0.92	1,565	11.48[b]	63	0.70[b]	505	0.98	129	0.93	1,100	0.81[b]
Pancreas	356	1.09	130	1.16	86	1.11	451	0.91[b]	102	0.91	1,371	0.96
Prostate	4,891	1.14[b]	1,332	0.92[b]	1,235	1.18[b]	6,023	0.94[b]	1,753	1.15[b]	54	—
Rectum and rectosigmoid junction	501	1.01	205	1.16[b]	104	0.88	819	1.10[b]	140	0.80[b]	1,915	0.95[b]
Kidney and other urinary organs[e]	846	11.08[b]	24	0.95	56	3.25[b]	145	1.28[b]	20	0.79	354	1.11
Stomach	328	1.04	130	1.18	67	0.89	583	1.15[b]	82	1.0	1,167	0.83[b]
Testis	13	1.23	2	0.32	4	1.00	6	0.44[b]	16	1.08	15	0.59[b]
Thyroid	39	0.97	31	1.85[b]	33	2.80[b]	67	1.13	50	2.20[b]	191	1.20[b]
Urinary bladder	728	0.71[b]	353	1.06	742	3.21[b]	1,486	1.00	349	0.97	4,515	1.05[b]

[a] Two-month latency period was used for generating SIRs.
[b] $p < .05$.
[c] Includes liver, gallbladder, intrahepatic bile duct, and other biliary.
[d] Includes lung, bronchus, trachea, mediastinum, and other respiratory organs.
[e] Includes kidney, renal pelvis, ureter, and other urinary organs.
—, multiple adenocarcinomas of the prostate not reportable.
Abbreviations: ONS, other nervous system; SIR, standardized incidence ratio.
Source: National Cancer Institute's SEER Program (SEER-9 areas).

mature database for examining the development of multiple primary malignancies; and (e) routine use of the data for research in cancer etiology, quality of care, and innovative statistical modeling.

Cancer incidence rates and trends are examined here in three ways: median age at diagnosis over time; comparison of summary incidence rates for four separate 5-year intervals spanning the time over which SEER data have been collected; and analysis of yearly incidence rates through modeling (joinpoint) and the determination of statistically significant APCs for trend segments over time. Median age at diagnosis has shifted slightly between 1974 and 2003, showing a small increase in age at diagnosis of about 2 years for cancer at all sites combined. For cancers common in young adults less than 40 years of age (e.g., bones and joints, Hodgkin lymphoma, acute lymphocytic leukemia, testis, and thyroid), the median age at diagnosis for all five sites has increased from 1974–1978 to 1999–2003 by 2–8 years.

Incidence data are frequently compared between two time periods of several years each to obtain sufficient cases for estimating rates. Although this method allows many aspects of the data to be observed, it does not show the detail available in an examination of yearly incidence rates over

Table 8. Observed cases and SIR for multiple primaries following diagnosis of an initial or index primary cancer in females, Surveillance, Epidemiology, and End Results (SEER-9 areas), 1973–2003[a]

	First primary cancer or index cancer													
	Urinary bladder		Oral cavity and pharynx		Kidney and renal		Colon and rectum		Melanoma of skin		Corpus and uterus		Breast	
Multiple primary sites	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR	Observed count	SIR
Brain and ONS	23	0.84	10	0.64	16	1.21	121	1.01	33	0.98	112	0.93	317	0.86[b]
Cervix uteri	20	0.69	27	1.32	18	1.15	144	1.03	19	0.41[b]	23	0.18[b,f]	333	0.73[b]
Colon excluding rectum	384	1.05	209	1.18[b]	156	1.02	2,819	1.60[b]	272	0.94	1,561	1.14[b]	4,249	1.02
Corpus and uterus, NOS	154	0.93	63	0.64[b]	87	1.08	858	1.17[b]	164	0.85[b]	33	0.04[b,f]	3,124	1.36[b]
Esophagus	19	1.03	185	18.71[b]	3	0.35	95	1.07	8	0.51	44	0.59[b]	298	1.31[b]
Eye and orbit	3	0.73	2	0.90	3	1.61	19	1.06	14	2.97[b]	10	0.57	53	1.01
Female breast	720	0.95	454	1.03	353	0.96	3,399	1.00	990	1.06	3,325	1.02	16,356	1.55[b]
Hodgkin lymphoma	7	1.21	4	1.11	2	0.67	18	0.70	11	1.14	22	0.90	73	0.92
Larynx	22	2.23[b]	64	10.19[b]	5	0.98	33	0.75	10	0.86	26	0.56[b]	124	0.86
Leukemia	100	1.30[b]	42	1.11	42	1.29	330	0.91	70	1.03	283	0.97	1,039	1.16[b]
Liver and other[c]	39	0.81	36	1.48[b]	17	0.82	179	0.76[b]	38	0.98	155	0.84[b]	439	0.77[b]
Lung and other respiratory organs[d]	786	2.14[b]	792	3.87[b]	243	1.36[b]	1,750	1.07[b]	365	0.95	1,286	0.80[b]	4,701	0.96[b]
Melanoma of the skin	65	1.17	30	0.93	38	1.39	227	0.96	823	8.94[b]	227	0.96	933	1.16[b]
Myeloma	41	1.04	17	0.82	20	1.11	183	0.96	21	0.63[b]	138	0.89	450	0.93
Non-Hodgkin lymphoma	103	0.90	71	1.20	61	1.19	536	1.03	147	1.28[b]	438	0.94	1,264	0.89[b]
Oral cavity and pharynx	49	1.02	806	29.54[b]	21	0.94	190	0.87[b]	52	1.04	146	0.71[b]	674	1.07
Ovary	97	1.04	51	0.95	27	0.61[b]	404	0.96	102	0.95	235	0.58[b,f]	1,601	1.27[b]
Pancreas	122	1.27[b]	61	1.28	49	1.19	434	0.94	67	0.87	344	0.94	993	0.89[b]
Rectum and rectosigmoid junction	103	0.99	67	1.24	46	1.02	653	1.33[b]	78	0.85	440	1.07	1,202	0.97
Kidney and other urinary organs[e]	215	17.79[b]	4	0.66	18	3.53[b]	59	1.04	6	0.61	63	1.33[b]	136	0.97
Stomach	64	1.18	36	1.32	28	1.23	308	1.12	30	0.77	175	0.89	698	1.13[b]
Thyroid	22	1.05	21	1.37	39	3.16[b]	108	1.16	75	1.61[b]	84	0.87	434	1.19[b]
Urinary bladder	170	1.88[b]	59	1.33[b]	334	8.70[b]	437	1.04	70	0.89	494	1.41[b]	1,102	1.04

[a] Two-month latency period was used for generating SIRs.
[b] $p < .05$.
[c] Includes liver, gallbladder, intrahepatic bile duct, and other biliary.
[d] Includes lung, bronchus, trachea, mediastinum, and other respiratory organs.
[e] Includes kidney, renal pelvis, ureter, and other urinary organs.
[f] Removal of target organs may reduce multiple primaries.
Abbreviations: NOS, not otherwise specified; ONS, other nervous system; SIR, standardized incidence ratio.
Source: National Cancer Institute's SEER Program (SEER-9 areas).

time. When adjusted for reporting delays, the age-adjusted incidence rates in men, which are primarily influenced by the rapidly changing trends in the diagnosis of asymptomatic prostate cancer, have been stable since 1995. For women, however, incidence rates continue to rise, influenced largely by changes in trends for cancers of the breast and lung. Detailed examination of breast cancer incidence shows stable rates in the most recent time period (2001–2003), preceded by a deceleration in the rate of increase since about 1987. Factors such as the reduction in use of hormone therapy among postmenopausal women that occurred following the 2002 publication of results from the Women's Health Initiative [22, 23] and population effects of screening practices with mammography [24] that may explain the recent stabilization and possible decline in breast cancer incidence rates are under investigation. Similarly, although incidence rates for female lung cancer are increasing, the rate of increase is slowing. Increases in the incidence rate for thyroid cancer in women are particularly notable, par-

Table 9. U.S. projected incidence counts through 2050 based on Surveillance, Epidemiology, and End Results (SEER) rates by sex for selected sites

Cancer sites	Age group	2000		2010		2020		2030		2040		2050	
		Count	Age (%)	Count	Age (%)	Count	Age (%)	Count	Age (%)	Count	Age (%)	Count	Age (%)
Males and females													
All sites	All ages	1,356,571	100	1,628,112	100%	2,007,391	100	2,385,611	100	2,655,908	100	2,862,564	100
	<45	122,625	9	118,665	7	123,378	6	132,256	5	137,321	5	149,316	5
	45–64	439,952	32	606,221	37	669,617	33	640,388	27	680,550	26	731,205	26
	65–84	692,215	51	757,175	47	1,041,025	52	1,383,925	58	1,470,513	55	1,484,476	52
	85+	101,779	8	146,051	9	173,371	9	229,042	10	367,524	14	497,567	17
Colon and rectum	All ages	152,232	100	183,367	100	228,174	100	281,390	100	325,740	100	356,162	100
	<45	6,185	4	5,832	3	6,022	3	6,511	2	6,664	2	7,295	2
	45–64	40,283	26	55,856	31	62,161	27	59,307	21	62,910	19	67,746	19
	65–84	86,716	57	94,345	51	127,544	56	172,706	62	187,382	58	187,999	53
	85+	19,048	13	27,334	15	32,447	14	42,866	15	68,784	21	93,122	26
Lung and bronchus	All ages	186,605	100	224,488	100	286,351	100	346,459	100	381,749	100	407,710	100
100%	<45	4,154	2	3,892	2	3,949	1	4,343	1	4,386	1	4,824	1
	45–64	53,890	29	76,099	34	86,446	30	81,961	24	86,427	23	93,824	23
	65–84	116,013	62	126,491	56	174,582	61	231,917	67	245,625	64	247,719	61
	85+	12,548	7	18,006	8	21,374	8	28,238	8	45,311	12	61,343	15
Female													
All sites	All ages	658,720	100	776,990	100	930,738	100	1,092,798	100	1,218,809	100	1,308,206	100
100%	<45	100	11	71,404	9	73,922	8	79,294	7	82,195	7	89,459	7
	45–64	218,677	33	296,023	38	320,070	35	305,593	28	324,193	26	345,650	26
	65–84	305,925	47	327,356	42	441,095	47	584,785	54	619,059	51	615,321	47
	85+	59,523	9	82,207	11	95,651	10	123,126	11	193,362	16	257,776	20
Breast	All ages	205,606	100	244,378	100	287,245	100	326,576	100	355,919	100	379,052	100
	<45	24,043	12	22,335	9	22,900	8	24,840	7	25,292	7	27,759	7
	45–64	87,838	43	117,463	48	125,063	43	119,986	37	127,884	36	135,604	36
	65–84	81,673	40	87,935	36	119,915	42	156,821	48	163,593	46	163,497	43
	85+	12,052	6	16,645	7	19,367	7	24,929	8	39,150	11	52,192	14
Male													
All sites	All ages	696,764	100	856,837	100	1,089,259	100	1,316,658	100	1,475,417	100	1,606,238	100
	<45	48,193	7	47,282	5	49,343	5	52,820	4	55,031	4	59,734	4
	45–64	221,216	32	310,336	36	349,938	32	335,491	25	357,561	24	387,319	24
	65–84	385,839	55	434,182	51	609,481	56	816,480	62	876,153	59	899,642	56
	85+	41,516	6	65,037	8	80,497	7	111,867	9	186,672	13	259,543	16
Prostate	All ages	212,521	100	265,681	100	348,385	100	418,024	100	457,383	100	495,522	100
	<45	957	0	903	0	895	0	1,009	1	1,007	0	1,112	0
	45–64	68,697	32	98,964	37	114,674	33	108,857	26	115,357	25	126,246	25
	65–84	132,844	63	150,112	57	213,382	61	281,150	67	295,951	65	305,503	62
	85+	10,023	5	15,702	6	19,434	6	27,008	6	45,068	10	62,661	13

Source: National Cancer Institute's SEER Program (SEER-17 areas); U.S. Census Bureau. Current population reports, P25-1092. Population projection for the United States by age, sex, race, and Hispanic origin: 1992–2050. Washington: U.S. Government Printing Office, 1996.

tially due to occurrence after diagnosis of other primary cancers [25].

Our study shows that women diagnosed with lung cancer have better survival than men, especially those diagnosed with local-stage disease. The reasons for this survival advantage have not been identified, but it is likely due to a variety of factors. A previous study [26] analyzing the SEER database suggests surgery was performed more frequently in women than in men with local-stage disease. Since surgery offers these patients the best chance of long-term survival, this difference in treatment may partially explain the superior survival observed in women. Other concomitant factors such as comorbidity can influence treatment decisions for surgery and adjuvant therapy. In ad-

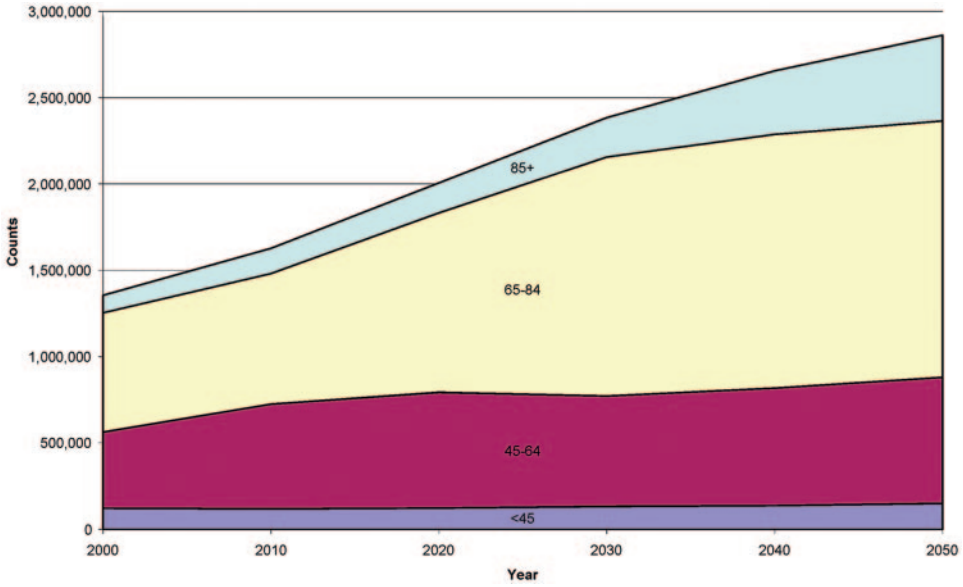

Figure 2. Projected number of cancer cases for 2000–2050 by age group (<45, 45–64, 65–84, 85^{+}) based on projected census population estimates and delay-adjusted SEER-17 cancer incidence rates. Projections based on approximate single-year delay-adjusted SEER-17 incidence rates for 1998–2002 and population projections from the U.S. Census Bureau.

dition, men and women smokers differ in the histological types of lung cancer with which they are diagnosed—women are more likely than men to develop adenocarcinoma [27]. This difference in histology may also influence survival. For patients with local disease, Fu et al. [26] reported a negative impact on survival with any histologic types (small cell, squamous cell, and large cell) other than adenocarcinoma after controlling for demographic, temporal, and treatment effects. Further study is needed to evaluate the biological basis and its impact on sex-specific survival differences in lung cancer patients.

The risk of developing cancer is often expressed in terms of lifetime risk, that is, the risk of a newborn developing cancer prior to death. Lifetime risk is confusing to many and assumes current rates hold over a person's entire lifetime. Shorter risk estimates (e.g., 10 years) conditional on a specific age are often much more understandable and meaningful when communicating risk. Data on risk of developing cancer in future years for men and women at 45 and 65 years of age are likely to be more relevant to patient concerns as they reach ages with established recommendations for cancer screening, as well as to clinicians who provide patient counseling concerning cancer prevention and early detection. In general, the risk of developing cancer increases with age, and differences in short-term risk are more pronounced by age (e.g., at birth, midlife, or retirement) than for long-term risk estimates. The risk of developing invasive cancer is generally higher for men than for women, except for risk associated with cancers occurring during the ages of 20–54 years when women have substantially higher cancer incidence rates than men [5].

Relative survival provides a measure of the excess mortality associated with a cancer diagnosis. The first source of major variation in survival is the particular cancer site. Stage at diagnosis is another major prognostic factor, and the decrease of survival with more advanced disease points to the importance of screening and early detection. However, cancers where early detection is less common, such as liver and pancreatic cancers, are among those with dismal overall relative survival rates. For early-stage lung cancer, a major cancer trial is underway to test the effectiveness of screening with spiral computed tomography imaging to diagnose early-stage disease [28].

In general, black patients have lower relative survival, independent of cancer site and stage at diagnosis. This health disparity may be partially due to variations in the prevalence of risk factors, the use of screening tests for early detection, access to health care services, and/or social and demographic factors [29].

Improvements in cancer survival affect cancer prevalence. As cancer survival improves and more individuals live longer after diagnosis, the prevalent population increases in size. This has led to a greater focus on several areas, such as long-term cancer treatment effects and their complications, issues that come into play in medical follow-up care. In addition, occupational, behavioral, and quality-of-life aspects of cancer survivorship are being addressed [30]. Prevalence provides information on the im-

Table 10. Complete cancer prevalence by sex and age as of January 1, 2003

	Males				Females			
Cancer sites	**All ages**	**≤49**	**50–69**	**70+**	**All ages**	**≤49**	**50–69**	**70+**
All sites	4,692,396	576,832	1,681,299	2,434,265	5,803,603	899,186	2,221,562	2,682,855
Acute lymphocytic leukemia	28,078	26,798	1,037	243	22,860	21,794	803	263
Breast	12,241	651	5,238	6,352	2,356,794	239,854	1,014,999	1,101,941
Cervix	NA	NA	NA	NA	253,781	67,739	103,498	82,544
Colon and rectum	514,794	25,583	173,640	315,571	553,409	24,018	144,260	385,131
Corpus and uterus, NOS	NA	NA	NA	NA	570,805	27,318	184,770	358,717
Esophagus	18,105	1,354	9,333	7,418	5,960	331	2,170	3,459
Hodgkin lymphoma	76,516	48,690	23,157	4,669	70,871	47,688	18,266	4,917
Kidney and renal pelvis	136,079	21,859	59,534	54,686	94,069	18,174	34,880	41,015
Larynx	78,071	3,256	32,397	42,418	19,243	1,566	8,047	9,630
Leukemia	112,323	42,895	34,025	35,403	86,690	34,551	21,439	30,700
Liver and IBD	10,851	2,404	5,421	3,026	6,494	1,909	2,361	2,224
Lung and bronchus	173,430	8,037	74,114	91,279	181,558	9,358	74,526	97,674
Melanoma of the skin	320,176	67,407	143,969	108,800	342,255	105,592	139,991	96,672
Myeloma	28,818	2,543	13,921	12,354	23,112	1,461	10,078	11,573
Non-Hodgkin lymphoma	189,637	45,720	78,608	65,309	174,846	29,285	65,556	80,005
Oral cavity and pharynx	150,051	19,608	68,270	62,173	85,582	13,542	32,512	39,528
Ovary	NA	NA	NA	NA	171,841	33,253	73,257	65,331
Pancreas	13,302	1,679	6,378	5,245	14,387	1,794	5,754	6,839
Prostate	1,937,808	14,803	639,593	1,283,412	NA	NA	NA	NA
Stomach	34,299	2,695	13,017	18,587	25,554	2,356	7,380	15,818
Urinary bladder	372,313	16,568	122,820	232,925	133,453	6,232	38,134	89,087

Prevalence was calculated using the First Malignant Primary Only for a person. NA, not applicable.
Abbreviations: IBD, intrahepatic bile duct; NOS, not otherwise specified.
Source: National Cancer Institute's SEER Program (SEER-9 areas).

pact of cancer on the health care system and documents the need for increased research on the needs of survivors.

The SEER Program is the sole source of U.S. population-based data to address issues associated with multiple primary cancers [31], using established rules for collecting and reporting more than one tumor per person. The SEER rules exclude recurrences or tumors of the same histology reporting within 2 months, with exceptions for some tumors such as retinoblastoma, bilateral ovarian tumors, adenocarcinomas of the prostate, certain bladder tumors, and a few others that are reported at one time. Analyses of multiple primaries presented here are based on a total population of over 2 million cancer patients diagnosed with cancer between 1973 and 2003 in the SEER-9 database, yielding approximately 12 million person-years at risk. For some initial cancer sites, a large proportion of multiple primary cancers occur at the same cancer site or organ system as the initial primary. This may be due to exposure, risk factors, or genetic predisposition. A process referred to as "field cancerization" involves effects of carcinogenic exposures or genetic factors over areas of tissues or organs [32]. Statistically significant increased multiple primaries in the same cancer site are reported for oral cavity and pharynx, kidney and renal pelvis, colon and rectum, and melanoma in both sexes, as well as urinary bladder and breast in women. The oral cavity and pharynx site seems to be the most extreme case, with SIRs of 29.5 and 11.5 in women and men, respectively.

Data are presented for various cancer sites, along with the percentage of multiple primaries found among those surviving more than 2 months, in addition to relative and observed 5-year survival among the cohorts. In general, an initial cancer site with a high percentage of multiple primaries must have a relatively high observed survival. For head and neck and urinary tract cancers (including oral cavity and pharynx and urinary bladder, the sites with the highest percentages of multiple primary cancers in Table 6), recent studies have shown evidence of a possible spread of cells

from a single clone to multiple sites [33, 34]. Factors involved in multiple primary cancers in separate sites may include the effects of risk factors such as tobacco and alcohol on multiple organs, infections and immunosuppression, genetic predisposition, and treatment effects [32]. Cancer of the thyroid is seen particularly frequently in these data with statistically increased SIRs associated with initial primary cancers of the oral cavity and pharynx, kidney and renal pelvis, melanoma, and prostate in men and of the kidney and renal pelvis, melanoma, and breast in women. As a shared environmental etiology is unlikely for some cancer pairs such as melanoma and thyroid cancer, a likely explanation at present for any relationship between these two tumor types continues to be increased medical surveillance [35]. Information on multiple primaries is important to clinicians and cancer patients during medical management following initial treatment as well as in efforts to minimize iatrogenic effects of cancer therapy identified through analyses of multiple primaries.

Projections into the future (through 2050) of the number of cancer cases and percentage of cases in four age groups show the effects of the changing age structure of the U.S. population. In this projection, with the cancer incidence rates held constant to current rates, the percentage of cancer patients for all sites combined in the 65–84-year age group increases to a peak in the year 2030 and then drops, whereas the number and percentage of cancer patients in the oldest age group continually increases. The population 85 years and older is the fastest-growing age sector of cancer patients. Our analysis indicates that, assuming constant cancer incidence rates, the number of cancer patients is expected to more than double from 1.36 million in 2000 to almost 3.0 million in 2050, due to aging and the growing U.S. population. This projection illustrates how cancer counts in a given age range may increase even when the incidence rate remains unchanged, due to the age structure of the population.

Substantial progress is being made against cancer for many, but not all, cancer sites and among many population groups, but not with equal effectiveness. These advances, however, have implications for health services needs in the future. As the prevalent population grows and more individuals live longer after a diagnosis of cancer, their medical care needs change. It is increasingly important to examine long-term treatment effects and to be aware of issues of multiple primary cancers. The population of individuals being treated for cancer is also aging, and projections for U.S. population dynamics will continue to age through the next half century. Thus, the patient population may have increased comorbid conditions that will affect both treatment decisions and healthcare during survivorship. We look to the SEER Program data as a continued source of information to chart these changing patterns as well as other aspects of the U.S. national cancer burden [36, 37].

Acknowledgments

We thank Don Green and Jennifer Stevens of Information Management Systems, Inc., for technical assistance and Terri Harshman, NCI, for editorial assistance.

Disclosures of Potential Conflicts of Interest

The authors indicate no potential conflicts of interest.

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Cancer Statistics, Trends, and Multiple Primary Cancer Analyses from the Surveillance, Epidemiology, and End Results (SEER) Program

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Oncologist 2007;12;20-37
DOI: 10.1634/theoncologist.12-1-20