Cancer Treatment and Survivorship Statistics, 2016

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ABSTRACT: The number of cancer survivors continues to increase because of both advances in early detection and treatment and the aging and growth of the population. For the public health community to better serve these survivors, the American Cancer Society and the National Cancer Institute collaborate to estimate the number of current and future cancer survivors using data from the Surveillance, Epidemiology, and End Results cancer registries. In addition, current treatment patterns for the most prevalent cancer types are presented based on information in the National Cancer Data Base and treatment-related side effects are briefly described. More than 15.5 million Americans with a history of cancer were alive on January 1, 2016, and this number is projected to reach more than 20 million by January 1, 2026. The 3 most prevalent cancers are prostate (3,306,760), colon and rectum (724,690), and melanoma (614,460) among males and breast (3,560,570), uterine corpus (757,190), and colon and rectum (727,350) among females. More than one-half (56%) of survivors were diagnosed within the past 10 years, and almost one-half (47%) are aged 70 years or older. People with a history of cancer have unique medical and psychosocial needs that require proactive assessment and management by primary care providers. Although there are a growing number of tools that can assist patients, caregivers, and clinicians in navigating the various phases of cancer survivorship, further evidence-based resources are needed to optimize care. **CA Cancer J Clin 2016;66:271-289. © 2016 American Cancer Society.**

Keywords: prevalence, statistics, survivorship, treatment patterns

Introduction

The number of cancer survivors continues to grow in the United States despite overall declining incidence rates in men and stable rates in women.[1] This reflects an increasing number of new cancer diagnoses resulting from a growing and aging population, as well as increases in cancer survival because of advances in early detection and treatment.

The American Cancer Society collaborates with the National Cancer Institute biennially to estimate the numbers of current and future cancer survivors to help the public health community better serve this unique population, some of whom must cope with long-term physical effects of treatment, as well as psychological and socioeconomic sequelae.[2] In this article, we use the term "cancer survivor" to describe any person who has been diagnosed with cancer, from the time of diagnosis through the remainder of his or her life. This includes patients currently undergoing treatment and those who may have become cancer-free. Throughout this article, the terms "cancer patient" and "survivor" are used interchangeably, although not all people with a history of cancer identify with the term "cancer survivor." We provide estimates for the most prevalent cancers, as well as statistics on treatment patterns and survival and issues related to survivorship.

Materials and Methods

Prevalence Estimates

Cancer prevalence as of January 1, 2016 was estimated using the Prevalence Incidence Approach Model, which calculates prevalence from cancer incidence and survival and all-cause mortality.[3] Incidence and survival were modeled by cancer

type, sex, and age group using invasive malignant cases (except urinary bladder, which included in situ cases) diagnosed from 1975 through 2012 from the 9 oldest registries in the population-based Surveillance, Epidemiology, and End Results (SEER) program (2014 submission data). For specific cancer site estimates, incident cases included the first primary for the specific cancer site between 1975 and 2012. This differs from previous prevalence projections,[4,5] which only included first ever malignant primaries and did not take into account subsequent primaries at different sites. Total cancer prevalence was calculated as in the previous methodology using only first ever primary cases.

Mortality data for 1975 through 2012 were obtained from the National Center for Health Statistics. Population projections from 2014 through 2026 were obtained from the US Census Bureau. Projected US incidence and mortality for 2013 to 2026 were calculated by applying 5-year average rates for 2008 through 2012 to the respective US population projections by age, sex, race, and year. Survival, incidence, and all-cause mortality rates were assumed to be constant from 2013 through 2026. For more information, see publications by Mariotto et al.[6,7]

2016 Case Estimates

The method for estimating the number of new US cancer cases in 2016 is described elsewhere.[1] Briefly, the total number of cases is estimated using a spatiotemporal model based on incidence data from 49 states and the District of Columbia for the years 1998 through 2012 that met the North American Association of Central Cancer Registries' high-quality data standard for incidence. Then, the number of new cases is temporally projected 4 years ahead using vector autoregression. This method considers geographic variations in sociodemographic and lifestyle factors, medical settings, and cancer screening behaviors as predictors of incidence and also accounts for expected delays in case reporting.

Stage at Diagnosis

Several different staging systems are used to classify cancers. In this report, the American Joint Committee on Cancer staging system,[8,9] which is commonly used in clinical settings, is used for the description of treatment patterns; whereas SEER Summary Stage, a staging system frequently used by population-based cancer registries, is used to describe population-based patterns of stage at diagnosis and survival.

Survival

There are 2 common measures of cancer survival: relative survival and observed survival. In this article, we use relative survival, which adjusts for normal life expectancy by comparing survival among cancer patients with that of the general population, controlling for age, race, and sex. The SEER 18 registries were the source for 5-year survival (diagnosis years 2005-2011). Data from the 9 oldest SEER registries are used to describe changes in survival over time. Many of these statistics were originally published in the *SEER Cancer Statistics Review, 1975-2012*.[10] In addition, 1-year, 10-year, and 15-year relative survival rates were generated for selected sites using the National Cancer Institute's SEER*Stat software (version 8.2.1).[11,12] One-year survival rates are based on cancer patients diagnosed from 2008 to 2011, 10-year survival rates are based on diagnoses from 1999 and 2011, and 15-year survival rates are based on diagnoses from 1994 and 2011; all patients were followed through 2012.

Treatment

Cancer treatment data were analyzed from 2 sources: the National Cancer Data Base (NCDB) and the SEER program.

NCDB

The NCDB is a hospital-based cancer registry jointly sponsored by the American Cancer Society and the American College of Surgeons. It includes approximately 70% of all invasive cancers in the United States from more than 1500 facilities accredited by the American College of Surgeons' Commission on Cancer (CoC).[13,14] Studies have shown that disease severity and treatment patterns in the NCDB stratified by clinical and sociodemographic factors for common cancer types are remarkably similar to those found in population-based registries.[15,16]

Treatment data are for cases diagnosed in the first 6 months of 2013 for all sites except testis, for which aggregated data from 2009 through 2013 were used because of the relatively small number of cases. In the 2013 NCDB data release, many common targeted therapy drugs are classified as chemotherapy. For this report, we also include drugs classified as immunotherapy in the chemotherapy category (chemotherapy does not include hormone therapy). For more information regarding drug classification categories, see the SEER-Rx Web site (seer.cancer.gov/tools/seerrx). Our analysis of treatment patterns does not include diagnostic procedures. Methods of drug delivery are not available in the NCDB, so topical or intravesical chemotherapy cannot be distinguished from systemic chemotherapy. More information can be found on the NCDB Web site (facs.org/cancer/ncdb).

SEER

The SEER 18 registries were the source for prostate cancer treatment patterns because data are substantially less complete in the NCDB.[11] However, use of androgen-

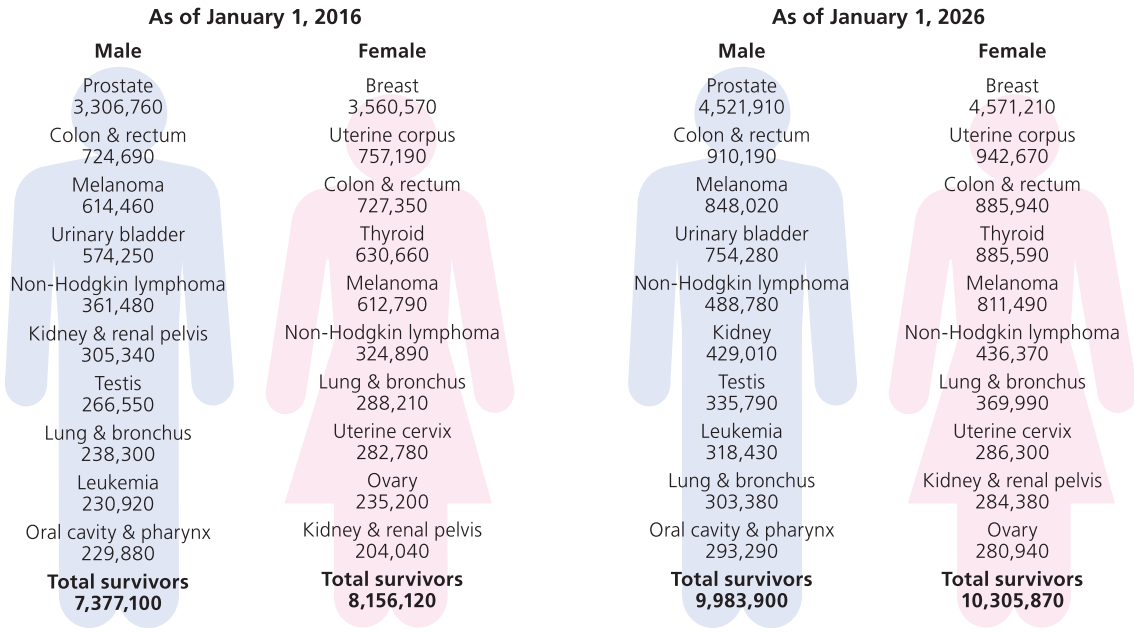


FIGURE 1. The Estimated Number of US Cancer Survivors.
Note: Estimates for specific cancer types take into account the potential for a history of more than one cancer type.
Source: Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD.

deprivation therapy is not collected, so could not be included.

Selected Findings: Cancer Prevalence

More than 15.5 million Americans with a history of cancer were alive on January 1, 2016. By January 1, 2026, this number is projected to reach 20.3 million (Fig. 1). These estimates do not include carcinoma in situ for any cancer except urinary bladder and do not include basal cell or squamous cell skin cancers. The 3 most prevalent cancers in 2016 are prostate (3,306,760), colon and rectum (724,690), and melanoma (614,460) among males and breast (3,560,570), uterine corpus (757,190), and colon and rectum (727,350) among females (Fig. 1). The distribution of cancer prevalence by type differs from that for new cases, reflecting differences in survival as well as age at diagnosis.

More than one-half (56%) of survivors were diagnosed within the past 10 years (Table 1). Twenty-one percent of female survivors were diagnosed more than 20 years ago compared to only 13% of males. Nearly one-half (47%) are age 70 years or older, although age distribution varies by cancer type (Table 2). For example, the majority of prostate cancer survivors (64%) are age 70 years or older, compared with only one-third of melanoma survivors (Fig. 2).

Selected Cancers

Breast (female)

It is estimated that there are more than 3.5 million women living in the United States with a history of invasive breast cancer, and an additional 246,660 women will be diagnosed in 2016. Seventy-five percent of breast cancer survivors (more than 2.6 million women) are ages 60 years or older, while 7% are younger than 50 years (Fig. 2).

Breast cancer tends to be diagnosed at a younger age than other common cancers, with a median age at diagnosis of 61 years compared with 70 years for lung cancer and 68 years for colorectal cancer (Fig. 3). About 19% of breast cancers are diagnosed in women ages 30 to 49 years, and 44% occur among women who are age 65 years or older.

Treatment and survival

Surgical treatment for breast cancer involves breast-conserving surgery (BCS, also known as partial mastectomy or lumpectomy) or mastectomy. When BCS followed by radiation to the breast is appropriately used for localized or regional cancers, long-term survival is the same as with mastectomy.[17,18] However, some patients require mastectomy because of tumor characteristics (eg, locally advanced stage, large or multiple tumors), because postsurgery radiation is contraindicated (eg, preexisting medical condition, such as active connective tissue disease), or other obstacles. Younger women (<40 years) and patients with larger and/or more aggressive tumors are more likely to be treated with mastectomy.[19,20] BCS-eligible women are increasingly electing mastectomy for a variety of reasons, including reluctance to undergo radiation therapy and fear of recurrence.[19] The proportion of women with nonmetastatic disease who undergo contralateral prophylactic mastectomy has also increased rapidly, from 5% of total mastectomies in 1998 to 30% in 2011.[21]

TABLE 1. Estimated Number of US Cancer Survivors as of January 1, 2016, by Sex and Time Since Diagnosis

	MALE AND FEMALE			MALE			FEMALE		
YEARS SINCE DIAGNOSIS	NO.	PERCENT	CUMULATIVE PERCENT	NO.	PERCENT	CUMULATIVE PERCENT	NO.	PERCENT	CUMULATIVE PERCENT
0 to <5 y	5,189,400	33	33	2,713,350	37	37	2,476,050	30	30
5 to <10 y	3,530,890	23	56	1,798,090	24	61	1,732,800	21	52
10 to <15 y	2,493,340	16	72	1,212,930	16	78	1,280,410	16	67
15 to <20 y	1,655,400	11	83	729,830	10	87	925,570	11	79
20 to <25 y	1,082,460	7	90	443,630	6	94	638,830	8	86
25 to <30 y	660,180	4	94	228,710	3	97	431,470	5	92
≥30 y	921,550	6	100	250,560	3	100	670,990	8	100

Note: Percentages do not sum to 100% due to rounding.

Source: Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute.

Among women diagnosed with stage I or II breast cancer, 61% undergo BCS (with the majority also receiving additional therapy) and 36% undergo mastectomy (Fig. 4). A much smaller percentage of stage III patients undergo BCS (21%), whereas 72% undergo mastectomy. Women diagnosed with stage IV disease most often receive radiation and/or chemotherapy alone (48%). Among women with hormone-receptor positive breast cancer of any stage, 79% receive hormonal therapy.[14]

Breast reconstruction for women who undergo mastectomy may involve the use of a saline or silicone implant, a tissue flap, or a combination thereof. Although reported rates of breast reconstruction in the United States vary widely, a recent large study found that the 57% of women with nonmetastatic disease who received mastectomies underwent reconstructive procedures.[21] Women who undergo bilateral mastectomy, are unmarried, or who have higher education or income are more likely to undergo reconstruction.[22]

The overall 5-year relative survival rate for female patients with breast cancer has improved in the past 3 decades, because of improvements in treatment (ie, chemotherapy, hormone therapy, and targeted drugs) and earlier detection through increased awareness and widespread use of mammography.[23] The 5-year, 10-year, and 15-year relative survival rates for breast cancer are 89%, 83%, and 78%, respectively.

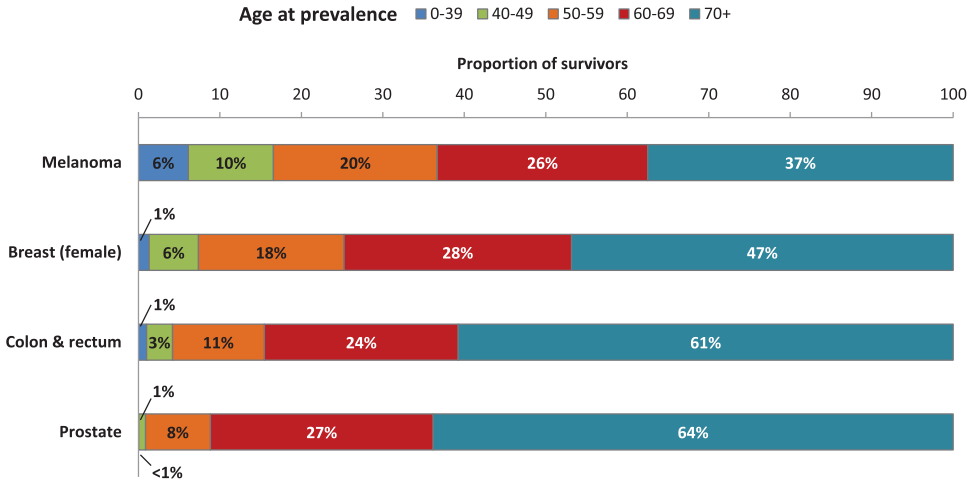
Cancer-related factors that influence survival include stage, tumor grade and histology, hormone receptor status, and human epidermal growth factor receptor 2 (HER2) status. Sixty-one percent of breast cancers are diagnosed at a localized stage, for which the 5-year relative survival rate is 99%. However, compared with white women, black women are less likely to be diagnosed with local stage breast cancer (53% vs 62%) and have lower survival within each stage.[10] These differences are driven in part by socioeconomic factors and differences in comorbidities, less access to and use of high-quality medical care among black women, and biological differences in cancers (eg, higher incidence of triple negative cancers among black women).[24–26]

TABLE 2. Estimated Number of US Cancer Survivors as of January 1, 2016, by Sex and Age at Prevalance

	MALE AND FEMALE			MALE			FEMALE		
	NO.	PERCENT	CUMULATIVE PERCENT	NO.	PERCENT	CUMULATIVE PERCENT	NO.	PERCENT	CUMULATIVE PERCENT
All Ages, y	15,533,220			7,377,100			8,156,120		
0–14	65,190	<1	<1	32,060	<1	<1	33,130	<1	<1
15–19	47,180	<1	1	23,610	<1	1	23,570	<1	1
20–29	187,490	1	2	90,730	1	2	96,760	1	2
30–39	408,790	3	5	166,170	2	4	242,620	3	5
40–49	958,600	6	11	347,700	5	9	610,900	7	12
50–59	2,389,670	15	26	963,410	13	22	1,426,260	17	30
60–69	4,141,950	27	53	2,027,150	27	49	2,114,800	26	56
70–79	4,011,790	26	79	2,148,940	29	79	1,862,850	23	79
≥80	3,322,560	21	100	1,577,330	21	100	1,745,230	21	100

Note: Percentages do not sum to 100% due to rounding.

Source: Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute.



Number of survivors on January 1, 2016 for selected cancer types

Age at prevalence	Melanoma	Breast (female)	Colon & rectum	Prostate
0-39	75,270	46,510	14,610	1,340
40-49	128,120	216,110	46,000	27,390
50-59	246,880	635,930	163,870	263,280
60-69	316,890	994,490	345,700	904,380
70+	460,090	1,667,530	881,870	2,110,380
All ages	1,227,250	3,560,570	1,452,040	3,306,760

FIGURE 2. Age Distribution of Survivors for Selected Cancer Types, January 1, 2016.
Percentages may not sum to 100% because of rounding.

Short-term and long-term health effects

Lymphedema of the arm occurs in 20% of women who undergo axillary lymph node dissection and in about 6% of women who undergo sentinel lymph node biopsy.[27] Early diagnosis of lymphedema is important for optimizing treatment and slowing progression.[28] Some forms of cancer rehabilitation may reduce the risk and lessen the severity of this condition.[29,30]

Other potential effects include numbness, tingling, or tightness in the chest wall, arms, or shoulders following surgery and/or radiation. Studies have shown that between 25% and 60% of women develop chronic pain after breast cancer treatment, although it is usually not severe.[31–33] In addition, treatment with chemotherapy can lead to impaired fertility and premature menopause, which increase the risk of osteoporosis.[34] Chemotherapy with taxanes often leads to neuropathy, which can persist long after treatment ends.[35] Anthracyclines and HER-2–targeted drugs can lead to cardiomyopathy and congestive heart failure.[36] Treatment with aromatase inhibitors, which is generally reserved for postmenopausal women, can also cause osteoporosis, as well as myalgia and arthralgia,[37] whereas tamoxifen treatment slightly increases the risk of endometrial cancer and thromboembolic disease.[38] Hormonal treatments may also cause menopausal symptoms, such as hot flashes, night sweats, and atrophic vaginitis, which can lead to dyspareunia.[39] Breast cancer survivors may also experience cognitive impairments and chronic fatigue.[30,40]

Cancers in Children and Adolescents

It is estimated that there are 65,190 cancer survivors aged birth to 14 years (children) and 47,180 survivors aged 15 to 19 years (adolescents) living in the United States as of January 1, 2016. An additional 10,380 children aged birth to 14 years will be newly diagnosed in 2016. The 3 most commonly diagnosed cancers in children are leukemia (30%), brain and central nervous system (CNS) tumors (26%, including benign and borderline tumors), and soft tissue sarcomas (7%), about one-half of which are rhabdomyosarcomas. Among adolescents, the most common cancers are brain and CNS tumors (20%), followed by leukemia (14%) and Hodgkin lymphoma (HL) (13%).[1]

Treatment and survival

Pediatric cancers are treated with a combination of therapies (surgery, radiation, chemotherapy, and targeted therapy) chosen based on the type and stage of cancer. Treatment often occurs in specialized centers and is

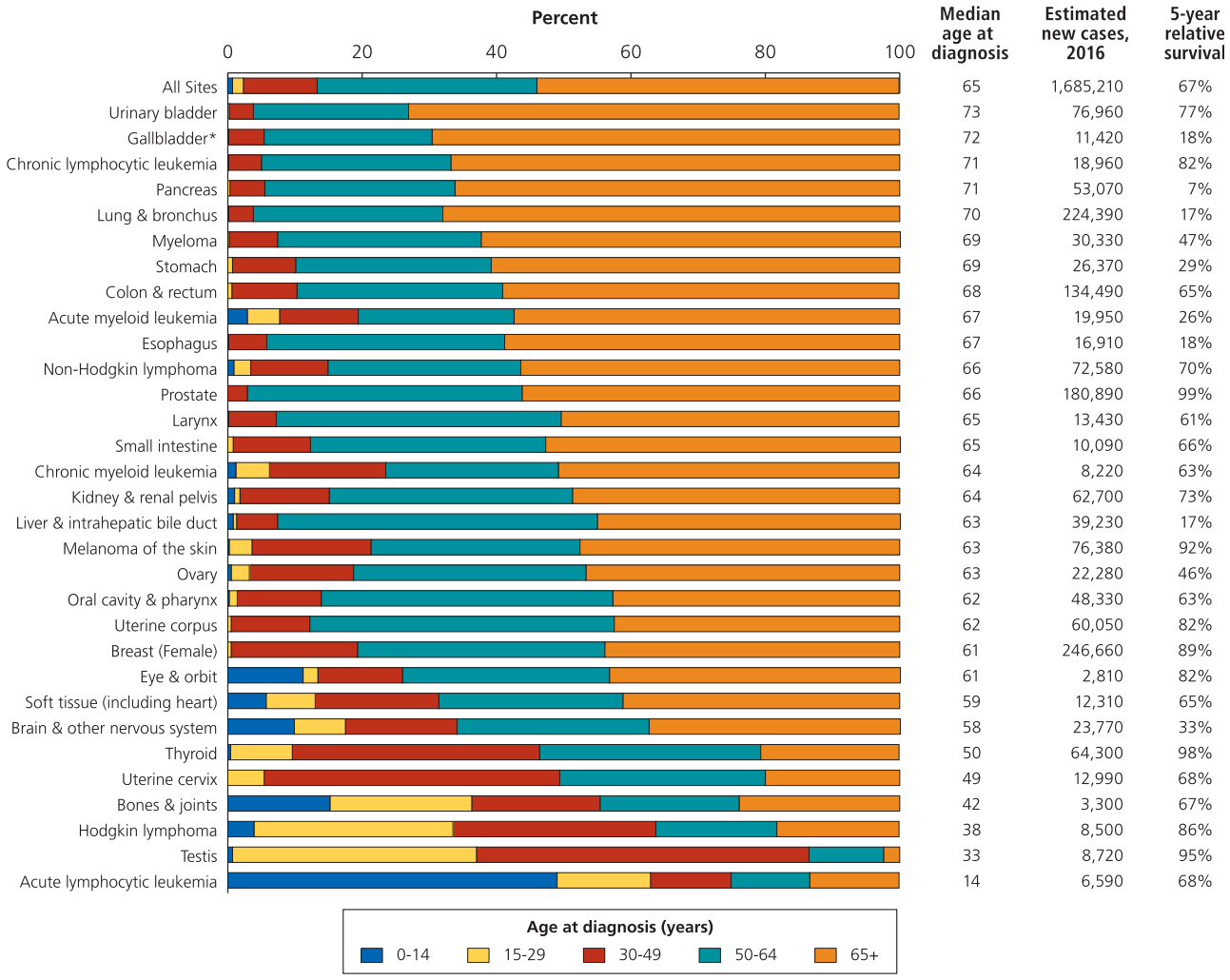


FIGURE 3. Age Distribution of New Cases (%), Median Age at Diagnosis, Estimated Number of New Cases, and 5-year Relative Survival by Cancer Type.

*The new case estimate includes other biliary cancers. Note that sites are ranked in order of the median age at diagnosis from oldest to youngest. Sources: Age distribution based on 2011 to 2012 data from the North American Association of Central Cancer Registries and excludes Arkansas and Nevada. The median age at diagnosis and 5-year relative survival are based on cases diagnosed during 2008 through 2012 and 2005 through 2011, respectively, from the Surveillance, Epidemiology, and End Results 18 registries and were previously published in Howlader et al,[10] and the 2016 estimated cases are from Siegel et al.[1]

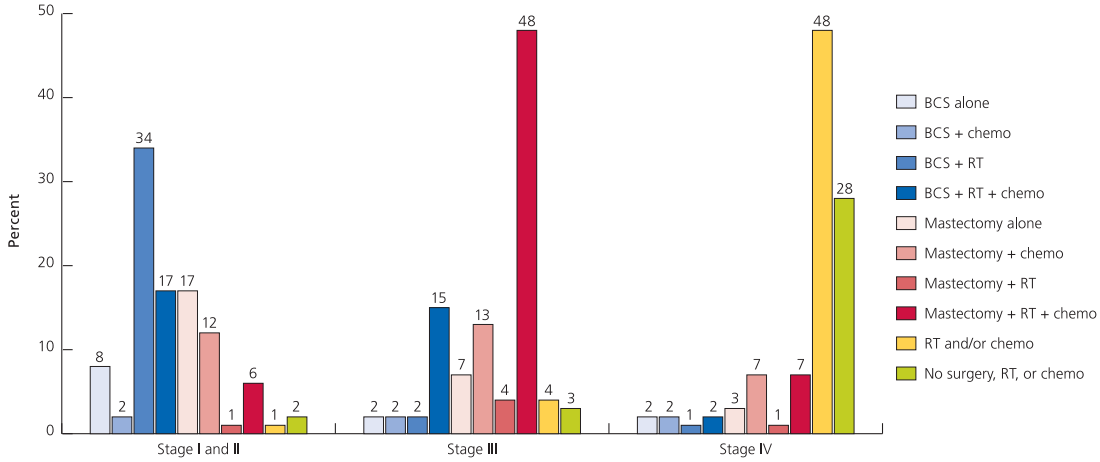


FIGURE 4. Female Breast Cancer Treatment Patterns (%) by Stage, 2013.

BCS indicates breast-conserving surgery; chemo, chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy. Source: National Cancer Data Base, 2013.

coordinated by a team of experts, including pediatric oncologists, surgeons and nurses, social workers, child life specialists, psychologists, and others.

Adolescents (ages 15-19 years) diagnosed with cancers that are more common in childhood are usually most appropriately treated at pediatric facilities or by pediatric specialists. For example, studies have shown that pediatric protocols result in better outcomes than adult protocols for adolescent patients with acute lymphocytic leukemia (ALL).[41] In addition, childhood cancer centers are more likely than adult cancer centers to offer adolescent patients the opportunity to participate in clinical trials.[42] For teen patients with cancers that are more common among adults, such as melanoma, testicular, and thyroid cancers, treatment by adult-care specialists is more appropriate.[43]

The overall 5-year relative survival rate for all childhood cancers (aged birth-14 years) combined has improved markedly over the past 30 years, from 58% for patients diagnosed between 1975 and 1977 to 83% for those diagnosed during 2005 through 2011, because of new and improved treatments. Although there has been less dramatic improvement in survival for adolescents, the current 5-year relative survival rate (84%) is similar to that for children.[10,44] However, survival rates vary considerably by cancer type. For example, the 5-year survival rate during 2005 through 2011 was 89% for children and 76% for adolescents for ALL, compared to 69% and 61%, respectively, for osteosarcoma.[10]

Short-term and long-term health effects

Childhood cancer survivors may experience both long-term (chronic) and late (occurring months or years after diagnosis or treatment) effects. Aggressive treatments used for childhood cancers, especially in the 1970s and 1980s, have resulted in several late effects, including increased risk of subsequent neoplasms and cardiomyopathies. A recent study found that 50% of childhood cancer survivors had developed a severe or life-threatening chronic health condition by age 50 years.[45] Among childhood cancer survivors who were diagnosed and treated between 1962 and 2001, 65% of those who were exposed to pulmonary toxic cancer treatments experienced pulmonary dysfunction, and 57% of those who were exposed to potentially cardiotoxic therapies experienced cardiac abnormalities.

Recent declines in late morbidity and mortality among childhood cancer survivors are due in part to reduced use of certain treatments, such as cranial radiation for ALL and abdominal radiation for Wilms tumor.[45] However, even many newer, less toxic therapies increase the risk of serious health conditions in long-term childhood cancer survivors.[46] Cognitive impairment, which can vary in severity, affects up to one-third of childhood cancer survivors.[47] In addition, surgery, radiation, and some chemotherapies affecting the reproductive organs may cause infertility in both males and females.[48,49] The potential impact on fertility and plans for fertility preservation should be discussed before commencing treatment. Treatment may delay maturation and normal development in survivors and lead to negative body image and psychological distress.[50]

Given these concerns, it is important that survivors of pediatric cancers are monitored for long-term and late effects as well as emotional and psychosocial concerns. The Children's Oncology Group, a National Cancer Institute-supported clinical trials group that cares for greater than 90% of US children and adolescents diagnosed with cancer, has developed long-term follow-up guidelines for the screening and management of late effects in survivors of childhood cancer (survivorshipguidelines.org).

Colon and Rectum

It is estimated that, as of January 1, 2016, there are more than 1.4 million men and women living in the United States with a previous colorectal cancer diagnosis, and an additional 134,490 cases will be diagnosed in 2016. Eighty-five percent of colorectal cancer survivors (about 1.2 million men and women) are aged 60 years and older, while only 4% (60,610) are aged younger than 50 years (Fig. 2). The median age at diagnosis for colorectal cancer is 66 years for males and 70 years for females.[10] Patients with rectal cancer tend to be younger at diagnosis than those with colon cancer (median age, 63 vs 70 years, respectively).

Treatment and survival

The majority of patients with stage I and II colon cancer undergo partial or total colectomy alone (84%), while about two-thirds of those with stage III disease (as well as some with stage II disease) receive chemotherapy in addition to colectomy to lower their risk of recurrence (Fig. 5). For patients with rectal cancer, proctectomy or proctocolectomy is the most common treatment (61%) for stage I disease, and about one-half also receive radiation and/or chemotherapy (Fig. 6). Stage II and III rectal cancers are often treated with neoadjuvant chemotherapy plus radiation. A colostomy (usually temporary) is required during surgery more often for patients with rectal cancer (29%) than for those with colon cancer (12%).[51] Chemotherapy is the main treatment for stage IV rectal cancers. Growing numbers of targeted drugs are also available to treat metastatic colorectal cancer.

The 5-year and 10-year relative survival rates for persons with colorectal cancer are 65% and 58%, respectively. When colorectal cancers are detected at a localized stage (39% of cases), the 5-year relative survival rate is 90%.

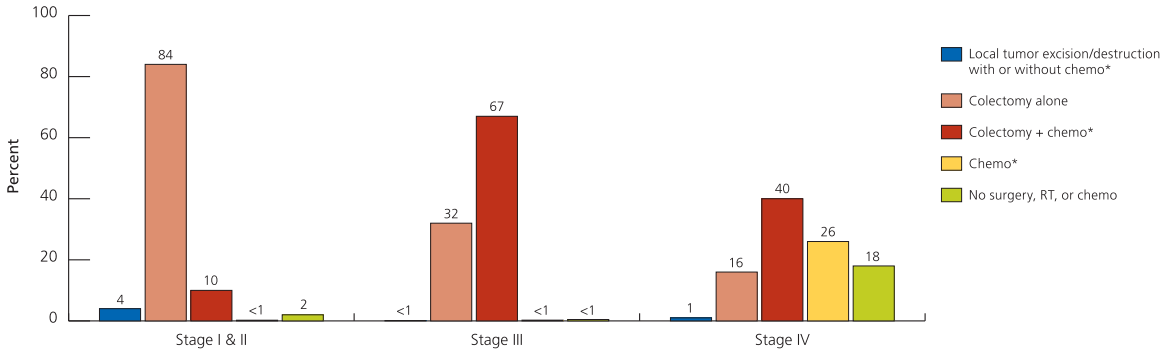


FIGURE 5. Colon Cancer Treatment Patterns (%) by Stage, 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy.
*A small number of these patients received RT. Source: National Cancer Data Base, 2013.

Short-term and long-term health effects

Neuropathy is a common side effect of chemotherapy regimens containing oxaliplatin.[52] Chronic diarrhea occurs in about one-half of colorectal cancer survivors.[53] Bowel dysfunction (including increased stool frequency, incontinence, radiation proctitis, and perianal irritation) is common among rectal cancer survivors, especially those treated with pelvic radiation.[54,55] Survivors may also suffer from bladder dysfunction, sexual dysfunction, and negative body image.[39,56,57] Referral to a trained ostomy therapist may benefit patients with a colostomy who experience these issues.[58] In addition, cancer recurrence is not uncommon among colorectal survivors,[59,60] who are also at increased risk of second primary cancers of the colon and rectum and other cancer sites, particularly those within the digestive system.[61]

Leukemias and Lymphomas

There are an estimated 407,950 leukemia survivors in the United States, and an additional 60,140 people will be diagnosed in 2016. Although leukemia is the most common type of cancer among children aged birth to 14 years, the majority (92%) of patients with leukemia are diagnosed at age 20 years and older.[62] Acute myeloid leukemia (AML) and chronic lymphocytic leukemia (CLL) are the most common types in adults, whereas ALL is most the common among children and teens (Fig. 3).

There are 2 basic categories of lymphoma: Hodgkin lymphoma (HL) and non-Hodgkin lymphoma (NHL). NHLs can be further divided into indolent and aggressive categories, each of which includes many subtypes that progress and respond to treatment differently. Prognosis and treatment depend on the stage and type of lymphoma. It is estimated that, as of January 1, 2016, there were 219,570 HL survivors and 686,370 NHL survivors. About 8500 new cases of HL and 72,580 new cases of NHL will be diagnosed in 2016. Although both HL and NHL occur in children and adults, the majority of HL cases (64%) are diagnosed before age 50 years, whereas most NHL cases (85%) occur in those aged 50 years and older (Fig. 3).

Treatment and survival for the most common types of leukemia and lymphoma

AML

Chemotherapy is the standard treatment for AML, although many older adults, among whom the disease is most common, are not able to tolerate the most aggressive and potentially curative protocols. Patients may also undergo allogeneic stem cell transplantation, and some

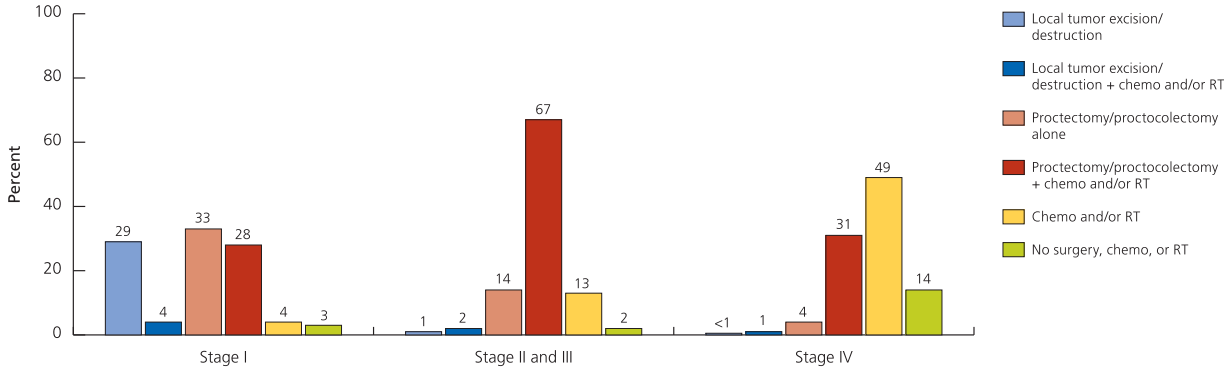


FIGURE 6. Rectal Cancer Treatment Patterns (%) by Stage, 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy. Source: National Cancer Data Base, 2013.

receive radiation therapy, often as part of a conditioning regimen before stem cell transplantation.

Approximately 60% to 85% of adults aged 60 years and younger with AML can expect to attain complete remission status after the first phase of treatment, and 35% to 40% of patients in this age group will be cured.[63,64] In contrast, 40% to 60% of patients aged older than 60 years will achieve complete remission, and only 5% to 15% will be cured. About 4% of AML cases occur in children and adolescents,[62] for whom the prognosis is substantially better. The 5-year relative survival rate for children and adolescents (aged birth-19 years) is 65% but declines to 50%, 32%, and 6% for patients aged 20 to 49 years, 50 to 64 years, and 65 years and older, respectively.

CML

Chronic myeloid leukemia (CML) is most common in adults, and only 2% of cases are diagnosed in children and adolescents.[62] The cancer cells in CML contain a characteristic fusion gene, *bcr-abl* (breakpoint cluster region-Abelson), which is caused by a translocation of genetic material between chromosomes 9 and 22, resulting in the Philadelphia chromosome. Modern treatment of CML has been transformed by tyrosine kinase inhibitors (TKIs) aimed at the BCR-ABL protein, which induce remission in most patients but must be taken indefinitely. Stem cell transplantation may be used in younger patients and those who become resistant to TKIs, whereas chemotherapy is only used in TKI-resistant patients. Primarily because of the discovery and widespread use of the BCR-ABL TKIs, the 5-year survival rate for CML increased from 31% for patients diagnosed during 1990 through 1992 to 63% for those diagnosed during 2005 through 2011.[10,65]

ALL

More than one-half of ALL cases (56%) are diagnosed in patients younger than 20 years. Chemotherapy is the standard treatment for ALL. About 20% to 30% of adult ALL cases and <5% of childhood cases are Philadelphia chromosome-positive and may benefit from the addition of a BCR-ABL TKI to chemotherapy.[66,67] More than 95% of children and from 78% to 92% of adults with ALL attain remission.[68] Allogeneic stem cell transplantation is recommended for some patients who have high-risk disease characteristics and for those who relapse after remission or who fail to achieve remission after successive courses of induction chemotherapy.

Survival rates for ALL have increased significantly over the past 3 decades, particularly among children.[10] Notably, the black-white 5-year relative survival disparity in children and adolescents with ALL has diminished from a 21-percentage-point difference during 1980 through 1984 (49% vs 70%) to a 3-percentage-point difference during 2005 through 2011 (89% vs 92%).[11] Survival declines with increasing age at diagnosis, and the current 5-year survival rate is 46% for patients aged 20 to 39 years, 30% for those aged 40 to 64 years, and 15% for those aged 65 years and older.

CLL

CLL is the most common type of leukemia in adults, and 95% of cases are diagnosed in individuals aged 50 years and older (Fig. 3). Treatment is generally reserved for symptomatic patients or for those who have cytopenia or other complications because the disease is slow-growing and treatment is unlikely to result in a cure. Available treatments include chemotherapy, immunotherapy, targeted therapy, radiation therapy, and splenectomy, but it is often not clear whether these treatments extend survival.[69–71] The overall 5-year relative survival rate for CLL is 82%; however, there is large variation in survival among individual patients, ranging from several months to a normal life expectancy. About 5% to 10% of patients with CLL develop diffuse large B-cell lymphoma (DLBCL), a process known as "Richter transformation."[72]

HL

There are 2 major types of HL. Classical HL (CHL) is the most common and is characterized by the presence of Reed-Sternberg cells. Nodular lymphocyte-predominant HL (NLPHL), which is characterized by "popcorn cells," comprises only about 5% of cases.[62] NLPHL is a more indolent disease with a generally favorable prognosis.[73]

CHL is generally treated with multiagent chemotherapy (88%), sometimes in combination with radiation therapy (30% among chemotherapy recipients), although the use of radiotherapy is declining.[14] If these treatments are not effective, stem cell transplantation or the targeted drug brentuximab vedotin may be options. For patients with NLPHL, radiation alone may be appropriate for early stage disease. For those with later stage disease, chemotherapy plus radiation as well as the monoclonal antibody rituximab may be recommended.

The 5-year and 10-year survival rates for HL are 86% and 80%, respectively. The 5-year survival rate is 94% for NLPHL and 85% for CHL.

NHL

The most common types of NHL are DLBCL, representing 37% of cases, and follicular lymphoma, representing 20% of cases.[62] Although DLBCLs grow quickly, most patients with localized disease and about 50% of those with advanced-stage disease are cured.[74,75] In contrast, follicular lymphomas tend to grow slowly and often do not require treatment until symptoms develop, but many are not curable.[76] Some cases of follicular lymphoma transform into DLBCL.

The first course of treatment for all NHL subtypes combined is usually chemotherapy, either alone (58%) or in combination with radiation (11%) (Fig. 7). Approximately 17% of patients receive no treatment. A monoclonal antibody like rituximab is often given along with chemotherapy for B-cell lymphomas and for some T-cell lymphomas.

The 5-year survival rate is 86% for follicular lymphoma and 61% for DLBCL; 10-year survival declines to 77% and 53%, respectively.

Short-term and long-term health effects

People treated for leukemia and lymphoma can experience several significant long-term and late effects. Some leukemia and lymphoma survivors, such as those who undergo stem cell transplantation, have problems with recurrent infections and with anemia, which may require blood transfusions. Certain chemotherapy drugs, as well as high-dose chemotherapy used for stem cell transplantation, can lead to infertility. Allogeneic transplantation used to treat acute leukemias can lead to chronic graft-versus-host disease, which can cause skin changes, dry mucous membranes (eyes, mouth, vagina), joint pain, weight loss, shortness of breath, and fatigue.

Chest radiation for HL increases the risk for cardiac dysfunction as well as breast cancer among women who were treated in childhood and adolescence. Patients with HL, NHL, and ALL are commonly treated with anthracyclines, which can also be cardiotoxic. In the past, some children with ALL who were at increased risk for CNS relapse received cranial radiation therapy. This treatment can cause long-term cognitive deficits, and it is used less frequently and at lower dosages today.[77]

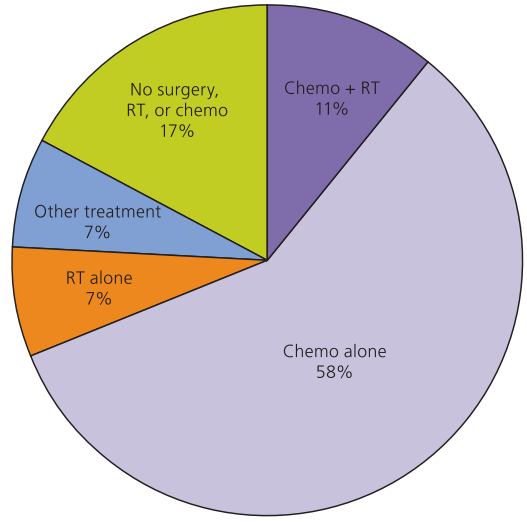


FIGURE 7. Non-Hodgkin Lymphoma Treatment Patterns (%), 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy. Source: National Cancer Data Base, 2013.

Lung and Bronchus

It is estimated that there are 526,510 men and women living in the United States with a history of lung cancer, and an additional 224,390 cases will be diagnosed in 2016. The median age at diagnosis for lung cancer is 70 years.

Treatment and survival

Lung cancer is classified as small cell (13% of cases) or nonsmall cell (83%) for the purposes of treatment (3% of cases in the SEER database lack information on histologic type).[10] Most patients with small cell lung cancer receive chemotherapy.[14] In addition, some patients are also treated with thoracic radiation therapy. For stage I and II nonsmall cell lung cancers (NSCLC), the majority of patients (69%) undergo surgery, and about 25% of surgical cases also receiving chemotherapy and/or radiation therapy (Fig. 8). Most patients with stage III and IV NSCLC receive chemotherapy with or without radiation (53%). Targeted therapy drugs, such as angiogenesis inhibitors, epidermal growth factor receptor (EGFR) inhibitors, and anaplastic lymphoma kinase (ALK) inhibitors, are also an important part of the treatment for NSCLC. Recently, immunotherapy drugs that act by targeting the programmed cell death receptor on T cells have been approved to treat some types of NSCLC.

The 1-year relative survival for lung cancer increased from 34% during 1975 through 1977 to 45% during 2008 through 2011, largely because of improvements in surgical techniques and chemoradiation. The majority of lung cancers (57%) are diagnosed at a distant stage, because early disease is typically asymptomatic; only 16% of cases are diagnosed at a local stage.[10] The 5-year survival rate is 55% for cases detected when the disease is still localized, 27% for regional disease, and 4% for distant stage disease. The 5-year survival for small cell lung cancer (7%) is lower than that for NSCLC (21%).

Short-term and long-term health effects

Many lung cancer survivors have impaired pulmonary function, although some may have had preexisting respiratory problems.[78] In some cases respiratory therapy and medications can improve fitness and allow survivors to resume normal daily activities. Treatment with EGFR inhibitors can lead to a severe acneiform rash. Immunotherapy drugs used in lung cancer treatment can lead to several immune mediated toxicities, including pneumonitis, colitis, nephritis, and endocrinopathy.

Lung cancer survivors who are current or former smokers are at increased risk for subsequent smoking-related cancers, especially lung, head and neck, and esophageal, as well as other smoking-related health problems. Survivors may feel stigmatized because of the social perception that lung cancer is a self-inflicted disease, which can be particularly

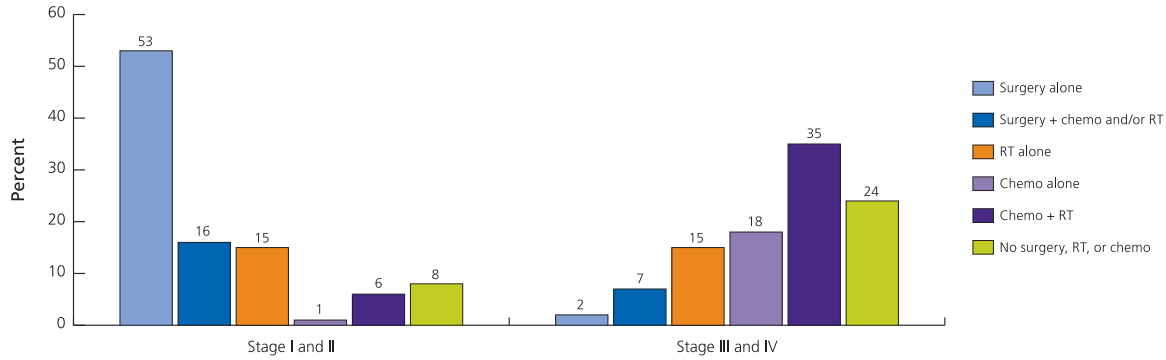


FIGURE 8. Nonsmall Cell Lung Cancer Treatment Patterns (%) by Stage, 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy. Source: National Cancer Data Base, 2013.

difficult for those who never smoked.[79] Data suggest that there is a benefit to smoking cessation even after a lung cancer diagnosis.[80,81]

Melanoma

It is estimated that there are more than 1.2 million melanoma survivors living in the United States, and an additional 76,380 people will be diagnosed in 2016. Sixty-three percent of melanoma survivors are under the age of 70, and 17% are under the age of 50 (Fig. 2). Melanoma incidence rates continue to increase in men but have recently stabilized in women.[1] Women tend to be diagnosed at a younger age than men (58 vs 65 years, respectively),[10] reflecting differences in occupational and recreational exposure to ultraviolet radiation, as well as early detection; women are more likely to be diagnosed at a localized stage, 86% versus 82% of men.

Treatment and survival

Surgery is the primary treatment for most melanomas. Patients with stage III disease may be offered adjuvant immunotherapy with interferon or the anticytotoxic T-lymphocyte-associated protein (anti-CTLA) antibody ipilimumab, although these treatments can have serious side effects. Treatment for patients with stage IV melanoma has changed in recent years and typically includes immunotherapy (ipilimumab, pembrolizumab, and nivolumab) or targeted therapy drugs, both of which have been shown to extend survival.[82–84] BRAF (B-Raf proto-oncogene, serine/threonine kinase) inhibitors have been shown to improve survival for melanomas with the *BRAF* gene mutation, which account for about one-half of all cases.[85–87] Almost one-half (46%) of patients with stage IV disease who receive either chemotherapy or immunotherapy also receive radiation therapy.[14]

The 5-year and 10-year relative survival rates for persons with melanoma are 92% and 89%, respectively. About 84% of melanomas are diagnosed at a localized stage, for which the 5-year survival rate is 98%.

Short-term and long-term health effects

Depending on the size and location of the melanoma, removal of these cancers can be disfiguring. Male and female melanoma survivors are nearly 13 and 16 times more likely, respectively, than the general population to develop additional melanomas because of skin type and other genetic or behavioral risk factors.[88] From 10% to 15% of patients treated with ipilimumab experience serious autoimmune-related side effects that sometimes can lead to death.[89] Autoimmune-related side effects occur less often with pembrolizumab and nivolumab. Patients treated with BRAF inhibitors have an increased risk of developing squamous cell skin carcinomas.

Prostate

It is estimated that there are more than 3.3 million men living with prostate cancer in the United States, and an additional 180,890 cases will be diagnosed in 2016. The majority (64%) of prostate cancer survivors are over the age of 70 years, and less than 1% are under age 50 years (Fig. 2). The median age at diagnosis is 66 years (Fig. 3). Most prostate cancers in the United States are diagnosed by prostate-specific antigen (PSA) testing, although many expert groups, including the American Cancer Society, have concluded that data on the efficacy of PSA screening are insufficient to recommend routine use of this test.[90]

Treatment and survival

Treatment options vary, depending on the extent of disease and the risk of recurrence, as well as patient characteristics, such as age and comorbidity, and personal preferences. Figure 9 shows primary treatment among men diagnosed during 2010 through 2012 based on SEER data [information on the use of androgen deprivation therapy (ADT) is not available] for all stages combined, although most (92%) of cases are diagnosed at the localized stage. Men younger than 65 years are most likely to be treated with radical prostatectomy (with or without radiation), whereas about one-half of men 75 years or older do not undergo surgery or radiation.

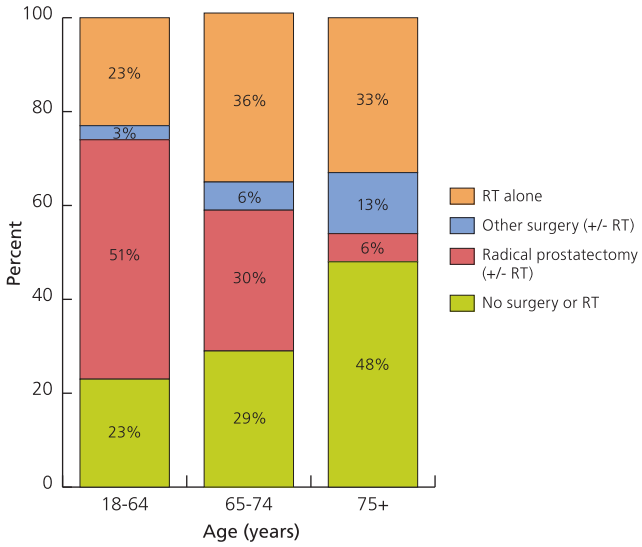


FIGURE 9. Prostate Cancer Treatment Patterns (%) by Age, United States, 2010-2012.

RT indicates radiation therapy. Patients with missing treatment data were excluded. Source: Surveillance, Epidemiology, and End Results (SEER) Program, SEER 18 Registries, 2010 to 2012.

Active surveillance rather than immediate treatment is a reasonable and commonly recommended approach, especially for men who have less aggressive tumors, are older, and/or have serious comorbid conditions.[91–93] ADT, chemotherapy, bone-directed therapy (such as zoledronic acid or denosumab), radiation, or a combination of these treatments are used to treat more advanced disease. Newer forms of hormone therapy, such as abiraterone and enzalutamide, have been approved in recent years to treat advanced prostate cancer that is no longer responding to traditional hormone therapy.[94–97]

The 5-year relative survival rate approaches 100% for patients with localized disease, but declines to 28% for those diagnosed at a distant stage. The 5-year relative survival for all stages combined increased from 83% in in the late 1980s to 99% in the most recent time period (2005-2011), primarily reflecting lead time and overdetection. The 10-year and 15-year relative survival rates are 98% and 95%, respectively.

Short-term and long-term health effects

Surgery and radiotherapy for prostate cancer are associated with risk of substantial physical impairments, including urinary incontinence, erectile dysfunction, and bowel complications.[98–101] In one long-term follow-up study, greater than 95% of patients with prostate cancer who underwent surgery or received radiation experienced some sexual dysfunction, and about 50% reported urinary or bowel dysfunction.[102] Patients receiving hormonal treatment may experience loss of libido, hot flashes, night sweats, irritability, and breast development. In the long term, ADT also increases the risk of osteoporosis, obesity, and diabetes.[103–106] Although some studies indicate an increased risk of cardiovascular disease or death associated with the use of hormone therapy, the evidence is inconsistent.[104,105,107] Careful monitoring of cardiovascular risk factors is recommended for men who have received ADT.[108,109]

Testis

It is estimated that there are 266,550 testicular cancer survivors in the United States, and an additional 8720 men will be diagnosed in 2016. Testicular germ cell tumors (TGCTs) account for approximately 97% of all testicular cancers.[62] The 2 main types of TGCTs are seminomas and nonseminomas. Nonseminomas are more common, generally occur in men in their late teens to early 40s, and tend to be more aggressive than seminomas. Seminomas are slow-growing and are generally diagnosed in men in their late 30s to early 50s.

Treatment and survival

Treatment of almost all TGCTs begins with orchiectomy. While the most common treatment for stage I and II seminomas is surgery alone (46%), many surgical patients also receive radiation (31%) or chemotherapy (22%) (Fig. 10). Over the last decade, postsurgical active surveillance has become an increasingly preferred management option for patients with stage I seminomas, and long-term study results support this treatment strategy.[110] Stage III and IV seminomas are generally treated with surgery and chemotherapy with or without radiation therapy (70%). Among patients with stage I and II nonseminomas, approximately 20% undergo retroperitoneal lymph node dissection, which is recommended to reduce the likelihood of recurrence (Fig. 11). Patients with stage III and IV nonseminomas are treated with surgery and adjuvant chemotherapy, and some require additional surgery after completion of chemotherapy.

The 5-year, 10-year, and 15-year survival rates are all approximately 95%. Most testicular cancers (68%) are diagnosed at a localized stage, for which the 5-year relative survival rate is 99%.

Short-term and long-term health effects

Although most men who have one healthy testicle produce sufficient male hormones and sperm to continue sexual relations and father children, sperm banking is recommended before treatment. Consultation about fertility risks before treatment and referral for sperm banking as appropriate are important in efforts to promote quality-of-life outcomes.

Retroperitoneal lymph node dissection can lead to retrograde ejaculation, making unassisted reproduction impossible. Men treated with chemotherapy have increased risks of coronary artery disease as they age, so these patients and

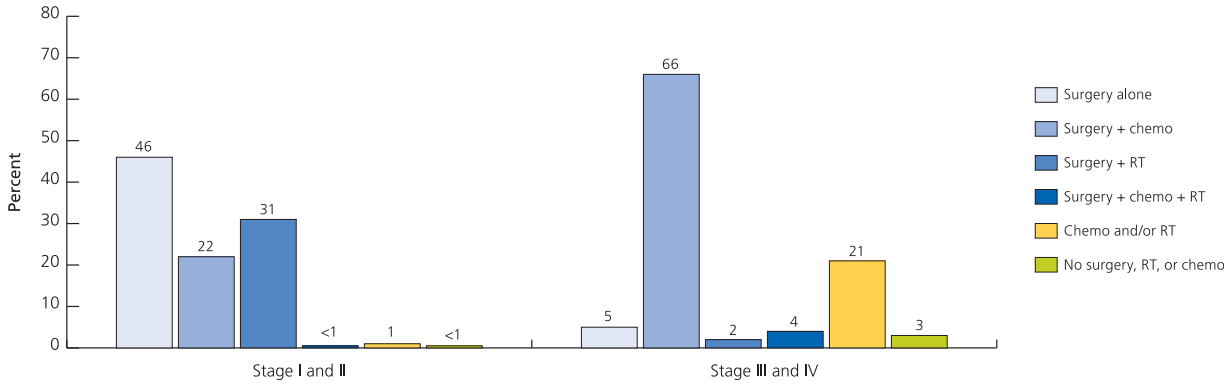


FIGURE 10. Treatment Patterns (%) for Seminomatous Testicular Germ Cell Tumors by Stage, 2009 to 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy. Source: National Cancer Data Base, 2013.

their physicians should be particularly mindful of risk factors like hyperlipidemia, hypertension, obesity, and smoking.[111] Men who have bilateral tumors have both testes removed and require lifelong testosterone supplementation.

Thyroid

It is estimated that there are 805,750 people living with a previous thyroid cancer diagnosis in the United States, and an additional 64,300 will be diagnosed in 2016. Thyroid cancer is the most rapidly increasing cancer in the United States[1] and has been increasing worldwide over the past few decades.[112] Studies suggest that the rise is primarily due to the increased incidental detection of indolent papillary tumors through widespread use of imaging.[113] Accumulating awareness of this "epidemic of diagnoses" has resulted in more conservative clinical practice guidelines about when to biopsy and a subsequent stabilization of overall incidence rates.[114] However, increasing trends for larger and follicular tumors indicate that risk factors may also be contributing to a true increase in disease occurrence.[115,116] The median age at diagnosis—54 years for males and 49 years for females—is younger than that for most other adult cancers (Fig. 3).

Treatment and survival

Most thyroid cancers are either papillary or follicular carcinomas, which are highly curable, but about 3% are medullary or anaplastic carcinomas,[10] which are more difficult to treat because they do not respond to radioactive iodine treatment.[117] These cancers also grow more quickly and often have metastasized by the time they are diagnosed.

The first choice of treatment in nearly all patients with thyroid cancer is surgery, with most patients undergoing total (86%) or partial (12%) thyroidectomy.[14] About one-half of surgically treated patients who have papillary or follicular thyroid cancer receive radioactive iodine (I-131) after surgery to destroy any remaining thyroid tissue and cancer.[118] After total thyroidectomy, thyroid hormone-replacement therapy is required and is often prescribed in a dosage sufficient to inhibit pituitary production of thyroid-stimulating hormone to decrease the likelihood of recurrence.

Total thyroidectomy is the primary treatment for patients with medullary thyroid cancer. When the tumor is extensive or cannot be completely resected, radiation therapy may be given after surgery. Targeted drugs can be useful in treating metastatic disease. Anaplastic thyroid cancers are often widespread and resistant to treatment; in selected

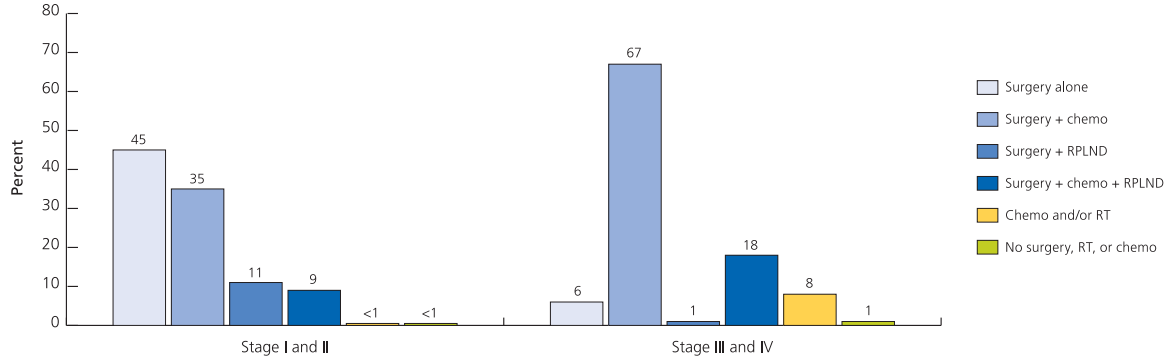


FIGURE 11. Treatment Patterns (%) for Nonseminomatous Testicular Germ Cell Tumors by Stage, 2009 to 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RPLND, retroperitoneal lymph node dissection; RT, radiation therapy. Note that a small proportion of patients (<1% of those with early stage disease and about 5% of those with late-stage disease) who underwent surgery also received RT. Source: National Cancer Data Base, 2013.

patients, radiation therapy alone or in combination with chemotherapy may be used.

The 5-year relative survival rate for patients with thyroid cancer who were diagnosed during 2005 through 2011 is 98%,[10] although survival varies by age at diagnosis, stage, and histologic type. Notably, blacks are more likely to be diagnosed at a localized stage compared with whites (78% vs 68%, respectively) but have lower survival within each stage and overall.[10] For patients with medullary and anaplastic carcinomas, the 5-year relative survival rates are 88% and 9%, respectively.[11]

Short-term and long-term health effects

Patients who undergo total thyroidectomy require thyroid hormone-replacement therapy, and thyroid hormone levels must be monitored to prevent hypothyroidism, which can cause cold intolerance and weight gain. Surgical removal of the thyroid gland can damage the underlying parathyroid glands, leading to disorders of calcium metabolism. Surgery can also damage nerves to the larynx and lead to voice changes. Treatment with radioactive iodine can affect fertility and may be linked to an increased risk of leukemia.[119] About 25% of medullary thyroid cancers occur as part of a genetic syndrome (such as multiple endocrine neoplasia [MEN] type 2), so these patients should be screened for other cancers and referred for genetic counseling and possible testing.[120]

Urinary Bladder

It is estimated that there are 765,950 urinary bladder cancer survivors living in the United States, and an additional 76,960 cases will be diagnosed in 2016. Bladder cancer incidence is about 4 times higher in men than in women.[62] The median age at diagnosis is 73 years. More than 70% of patients who have bladder cancer are diagnosed with nonmuscle-invasive disease.[11]

Treatment and survival

For nonmuscle-invasive cancers, most patients are diagnosed and treated with transurethral resection of the bladder tumor (TURBT), which may be followed by intravesical chemotherapy (22%) or biologic therapy with bacillus Calmette-Guerin (29%).[14] (The NCDB does not distinguish between systemic and intravesical chemotherapy but, based on treatment guidelines, it is likely that virtually all chemotherapy is intravesical administration.)

Among patients with muscle-invasive disease, about one-half undergo TURBT, and 39% undergo cystectomy, with or without chemotherapy and/or radiation (Fig. 12). TURBT followed by combined chemotherapy and radiation therapy is as effective as cystectomy at preventing recurrence in appropriately selected cases.[121–123] Chemotherapy is usually the first treatment for cancers that have metastasized, but other treatments might be used as well.

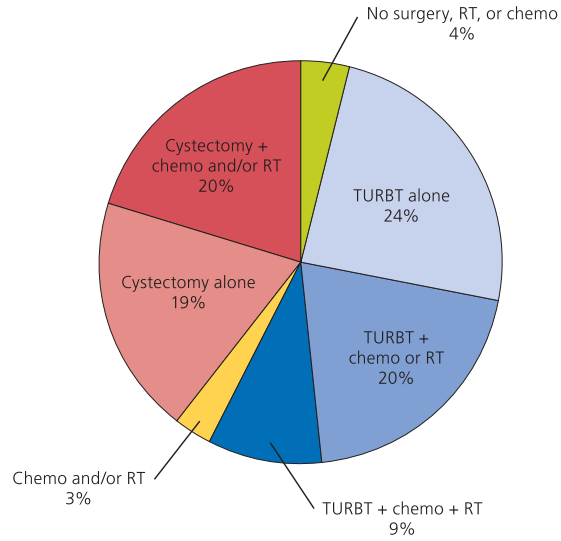


FIGURE 12. Muscle-invasive Bladder Cancer Treatment Patterns (%), 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy; TURBT, transurethral resection of the bladder tumor. Source: National Cancer Data Base, 2013.

For all stages combined, the 5-year relative survival rate is 77%.[10] Survival declines to 70% at 10 years and to 65% at 15 years after diagnosis. The 5-year relative survival rate for in situ urinary bladder cancer, which accounts for 51% of cases, is 96%.[10] For the 35% of patients with invasive tumors diagnosed at a localized stage, the 5-year survival rate is 70% (81% for those with nonmuscle-invasive disease and 47% for those with muscle-invasive disease).

Short-term and long-term health effects

Posttreatment surveillance is crucial given the high rate of recurrence (estimates range from 50% to 90%).[124,125] Surveillance can include screening for urine biomarkers and cytology as well as cystoscopy. Patients who require repeated bladder surgeries can end up with a small or scarred bladder, which may lead to urinary frequency or incontinence. Partial cystectomy results in a smaller bladder, sometimes causing the patient to have more frequent urination. Patients undergoing cystectomy in which the entire bladder is removed require urinary diversion with either construction of a neobladder with urethral anastomosis or a urostomy. Those with a neobladder retain most of their urinary continence after appropriate rehabilitation.[126] However, creation of a neobladder remains much less common than urostomy (9% vs 91%), largely because of the technical complexity of the procedure; its use is substantially higher at larger, higher volume hospitals.[127] Younger, healthier patients and those who are male are also more likely to undergo the procedure.

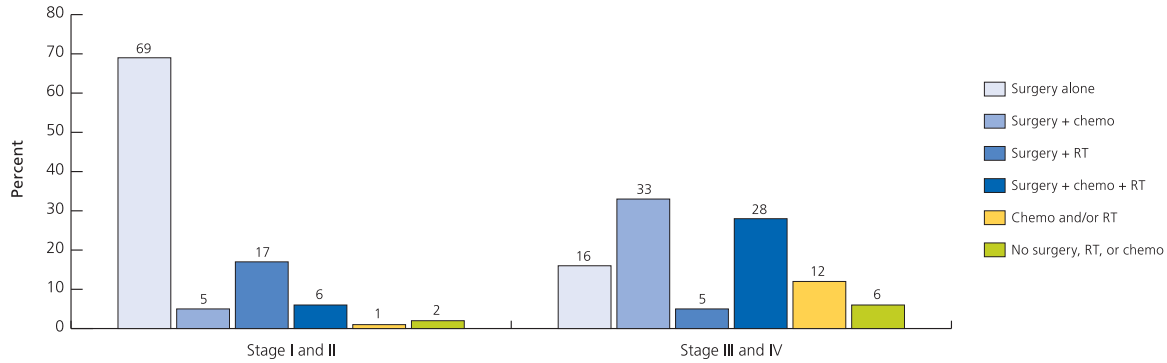


FIGURE 13. Uterine Corpus Cancer Treatment Patterns (%) by Stage, 2013.
Chemo indicates chemotherapy (includes immunotherapy and targeted therapy); RT, radiation therapy. Source: National Cancer Data Base, 2013.

Uterine Corpus

There are an estimated 757,190 women living in the United States with a previous diagnosis of uterine corpus cancer and an additional 60,050 cases will be diagnosed in 2016. Cancer of the uterine corpus is the second most prevalent cancer among women after breast cancer. The median age at diagnosis is 62 years (Fig. 3).

Treatment and survival

Surgery, consisting of hysterectomy (often including bilateral salpingo-oophorectomy) alone, is used to treat 69% of patients with stage I and II disease, whereas 28% of women receive radiation and/or chemotherapy in addition to surgery (Fig. 13). Two-thirds of women with stage III and IV disease undergo surgery followed by radiation and/or chemotherapy. Clinical trials are currently assessing the most appropriate regimen of radiation and chemotherapy for women with metastatic or recurrent cancers.

The 5-year and 10-year relative survival rates for women with uterine corpus cancer are 82% and 79%, respectively. Most cancers (67%) are diagnosed at an early stage, usually because of postmenopausal bleeding, for which the 5-year survival rate is 95%. The overall 5-year survival for white women (84%) is about 22 percentage points higher than that for black women (62%).[10]

Short-term and long-term health effects

Any hysterectomy causes infertility. Bilateral oophorectomy will cause menopause in premenopausal women, which can lead to symptoms such as hot flashes, night sweats, atrophic vaginitis, and osteoporosis. Long-term side effects of radiation therapy for uterine cancer can include bladder and bowel dysfunction as well as atrophic vaginitis and stenosis. Sexual problems are commonly reported among uterine cancer survivors.[128] Pelvic lymphadenectomy can lead to lower extremity lymphedema, particularly for women who also receive radiation.[129]

Quality of Life and Other Concerns in Long-Term Survivorship

Although quality of life may decline considerably during active cancer treatment and remain low for a short period thereafter, many side effects are acute and short-lived, and the majority of disease-free cancer survivors report good quality of life 1 year posttreatment. The type and prevalence of long-term or late side effects vary with clinical factors (eg, cancer type, treatment) and patient characteristics (eg, age, sex, comorbidity). While emotional well-being for longer term survivors (≥5 years) is generally comparable to that of individuals with no history of cancer, a significant number report lower overall physical well-being than their peers.[2,130] Many survivors also suffer from a fear of recurrence and subsequent primary cancers.[131] Quality-of-life issues also encompass the concerns of cancer caregivers, who provide substantial emotional and physical support to survivors and who frequently report having unmet psychosocial and medical needs.[132]

There is increasing emphasis on improving cancer survivors' overall well-being and quality of life through the application of principles of disease self-management and the promotion of healthy lifestyles, such as avoiding tobacco, maintaining a healthy body weight, avoiding intense ultraviolet radiation exposure, and being physically active throughout life. Several practical interventions for survivors addressing diet, weight, and physical activity among cancer survivors have been developed and tested.[133] In addition, support for smoking cessation and increased access to cessation aids are essential, because approximately 10% of cancer survivors continue to smoke even up to 9 years after diagnosis.[134] Younger cancer survivors in particular have been shown to have a higher prevalence of smoking after diagnosis than the general population.[135]

It is therefore important for providers to understand the unique medical and psychosocial needs of survivors as well as their caregivers and to be aware of resources that can assist in navigating the various phases of cancer survivorship. The American College of Surgeons' CoC has issued

standards for quality, patient-centered cancer care that include recommendations for patient navigation, palliative care, distress management, and survivorship care planning.[136] The Alliance for Quality Psychosocial Cancer Care, a coalition of professional and advocacy organizations, including the American Cancer Society, formed to advance these recommendations and issued a comprehensive resource guide, which is available to assist CoC-accredited facilities in meeting the new standards.[137] Several organizations, including the American Cancer Society,[30,58,109,138] have begun to produce guidelines to assist primary care and other survivorship physicians in the provision of care for people with a history of cancer. The ACS guidelines focus on comprehensive survivorship care, including ongoing surveillance and cancer screening, support for health behavior changes, and the assessment and management of the long-term and late effects of cancer and its treatment.

Conclusion

In this article, we document the continued growth of the cancer survivor population in the United States and describe patterns of treatment and common side effects across the most prevalent cancers. Despite increasing awareness of survivorship issues and the resiliency of cancer survivors, many challenges remain. These include a fractured health care system, poor integration of survivorship care between oncology and primary care settings, lack of strong evidence-based guidelines for posttreatment care, and financial and other barriers to quality care, particularly among the medically underserved. To address these challenges, ongoing efforts to identify best practices for the delivery of quality posttreatment cancer care are needed. Future research should also focus on identifying the best methods for encouraging cancer survivors to adopt and maintain a healthy lifestyle. Models for the integration of comprehensive care for cancer survivors, including self-management, wellness and healthy lifestyle promotion, and cancer rehabilitation, are beginning to emerge. As the evidence base grows, efforts at the individual, provider, system, and policy levels will help cancer survivors live longer and healthier lives. ■

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References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. *CA Cancer J Clin.* 2016;66:7-30.
2. Weaver KE, Forsythe LP, Reeve BB, et al. Mental and physical health-related quality of life among US cancer survivors: population estimates from the 2010 National Health Interview Survey. *Cancer Epidemiol Biomarkers Prev.* 2012;21:2108-2117.
3. Verdecchia A, De Angelis G, Capocaccia R. Estimation and projections of cancer prevalence from cancer registry data. *Stat Med.* 2002;21:3511-3526.
4. DeSantis CE, Lin CC, Mariotto AB, et al. Cancer treatment and survivorship statistics, 2014. *CA Cancer J Clin.* 2014;64:252-271.
5. Siegel R, DeSantis C, Virgo K, et al. Cancer treatment and survivorship statistics, 2012. *CA Cancer J Clin.* 2012;62:220-241.
6. Mariotto AB, Yabroff KR, Feuer EJ, De Angelis R, Brown M. Projecting the number of patients with colorectal carcinoma by phases of care in the US: 2000-2020. *Cancer Causes Control.* 2006;17:1215-1226.
7. Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010-2020. *J Natl Cancer Inst.* 2011;103:117-128.
8. Greene FL, Page DL, Fleming ID, et al, eds. AJCC Cancer Staging Manual. 6th ed. New York: Springer-Verlag; 2002.
9. Edge S, Byrd DR, Compton CC, Fritz AG, Greene FL, Trotti A, eds. AJCC Cancer Staging Manual. 7th ed. New York: Springer; 2010.
10. Howlader N, Noone AM, Krapcho M, et al. SEER Cancer Statistics Review, 1975–2012. seer.cancer.gov/csr/1975_2012/ (based on November 2014 SEER data submission). Bethesda, MD: National Cancer Institute, 2015.
11. Surveillance, Epidemiology, and End Results (SEER) Program. SEER*Stat Database: Incidence-SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2014 Sub (1973-2012 varying)-Linked To County Attributes-Total US, 1969–2013 Counties. Bethesda, MD: National Cancer Institute, Department of Cancer Control and Population Sciences, Surveillance Research Program, Surveillance Systems Branch; 2015.
12. Surveillance Research Program, National Cancer Institute. SEER*Stat software, version 8.2.1. Bethesda, MD: National Cancer Institute; 2015.
13. Lerro CC, Robbins AS, Phillips JL, Stewart AK. Comparison of cases captured in the national cancer data base with those in population-based central cancer registries. *Ann Surg Oncol.* 2013;20:1759-1765.
14. American College of Surgeons, Commission on Cancer. National Cancer Database, 2013 Data Submission. Chicago, IL: American College of Surgeons; 2015.
15. Fedewa SA, Ward EM, Stewart AK, Edge SB. Delays in adjuvant chemotherapy treatment among patients with breast cancer are more likely in African American and Hispanic populations: a national cohort study 2004-2006. *J Clin Oncol.* 2010;28:4135-4141.
16. Bhargava A, Du XL. Racial and socioeconomic disparities in adjuvant chemotherapy for older women with lymph node-positive, operable breast cancer. *Cancer.* 2009;115:2999-3008.
17. Jatoi I, Proschan MA. Randomized trials of breast-conserving therapy versus mastectomy for primary breast cancer: a pooled analysis of updated results. *Am J Clin Oncol.* 2005;28:289-294.
18. Litiere S, Werutsky G, Fentiman IS, et al. Breast conserving therapy versus mastectomy for stage I-II breast cancer: 20 year follow-up of the EORTC 10801 phase 3 randomised trial. *Lancet Oncol.* 2012;13:412-419.
19. McGuire KP, Santillan AA, Kaur P, et al. Are mastectomies on the rise? A 13-year trend analysis of the selection of mastectomy versus breast conservation therapy in 5865 patients. *Ann Surg Oncol.* 2009;16:2682-2690.
20. Freedman RA, Virgo KS, Labadie J, He Y, Partridge AH, Keating NL. Receipt of locoregional therapy among young women with breast cancer. *Breast Cancer Res Treat.* 2012;135:893-906.
21. Kummerow KL, Du L, Penson DF, Shyr Y, Hooks MA. Nationwide trends in mastectomy for early-stage breast cancer. *JAMA Surg.* 2015;150:9-16.
22. Freedman RA, Kouri EM, West DW, et al. Higher stage of disease is associated with bilateral mastectomy among patients with breast cancer: a population-

based survey. *Clin Breast Cancer.* 2016; 16:105-112.

23. Berry DA, Cronin KA, Plevritis SK, et al. Effect of screening and adjuvant therapy on mortality from breast cancer. *N Engl J Med.* 2005;353:1784-1792.
24. Vona-Davis L, Rose DP. The influence of socioeconomic disparities on breast cancer tumor biology and prognosis: a review. *J Womens Health (Larchmt).* 2009;18:883-893.
25. Danforth DN Jr. Disparities in breast cancer outcomes between Caucasian and African American women: a model for describing the relationship of biological and nonbiological factors [serial online]. *Breast Cancer Res.* 2013;15:208.
26. Curtis E, Quale C, Haggstrom D, Smith-Bindman R. Racial and ethnic differences in breast cancer survival: how much is explained by screening, tumor severity, biology, treatment, comorbidities, and demographics? *Cancer.* 2008;112:171-180.
27. DiSipio T, Rye S, Newman B, Hayes S. Incidence of unilateral arm lymphoedema after breast cancer: a systematic review and meta-analysis. *Lancet Oncol.* 2013;14: 500-515.
28. Lawenda BD, Mondry TE, Johnstone PA. Lymphedema: a primer on the identification and management of a chronic condition in oncologic treatment. *CA Cancer J Clin.* 2009;59:8-24.
29. Shaitelman SF, Cromwell KD, Rasmussen JC, et al. Recent progress in the treatment and prevention of cancer-related lymphedema. *CA Cancer J Clin.* 2015;65:55-81.
30. Runowicz CD, Leach CR, Henry NL, et al. American Cancer Society/American Society of Clinical Oncology Breast Cancer Survivorship Care Guideline. *J Clin Oncol.* 2016;34:611-635.
31. Gartner R, Jensen MB, Nielsen J, Ewertz M, Kroman N, Kehlet H. Prevalence of and factors associated with persistent pain following breast cancer surgery. *JAMA.* 2009;302:1985-1992.
32. Vilholm OJ, Cold S, Rasmussen L, Sindrup SH. The postmastectomy pain syndrome: an epidemiological study on the prevalence of chronic pain after surgery for breast cancer. *Br J Cancer.* 2008;99:604-610.
33. Steegers MA, Wolters B, Evers AW, Strobbe L, Wilder-Smith OH. Effect of axillary lymph node dissection on prevalence and intensity of chronic and phantom pain after breast cancer surgery. *J Pain.* 2008;9: 813-822.
34. Howard-Anderson J, Ganz PA, Bower JE, Stanton AL. Quality of life, fertility concerns, and behavioral health outcomes in younger breast cancer survivors: a systematic review. *J Natl Cancer Inst.* 2012;104: 386-405.
35. Rivera E, Cianfrocca M. Overview of neuropathy associated with taxanes for the treatment of metastatic breast cancer. *Cancer Chemother Pharmacol.* 2015;75:659-670.
36. Curigliano G, Cardinale D, Suter T, et al. Cardiovascular toxicity induced by chemotherapy, targeted agents and radiotherapy: ESMO Clinical Practice Guidelines. *Ann Oncol.* 2012;23(suppl 7):vii155-vii166.
37. Conte P, Frassoldati A. Aromatase inhibitors in the adjuvant treatment of postmenopausal women with early breast cancer: putting safety issues into perspective. *Breast J.* 2007;13:28-35.
38. Early Breast Cancer Trialists' Collaborative Group (EBCTCG), Davies C, Godwin J, et al. Relevance of breast cancer hormone receptors and other factors to the efficacy of adjuvant tamoxifen: patient-level meta-analysis of randomised trials. *Lancet.* 2011;378:771-784.
39. Schover LR, van der Kaaij M, van Dorst E, Creutzberg C, Huyghe E, Kiserud CE. Sexual dysfunction and infertility as late effects of cancer treatment. *EJC Suppl.* 2014;12:41-53.
40. Pinto AC, de Azambuja E. Improving quality of life after breast cancer: dealing with symptoms. *Maturitas.* 2011;70:343-348.
41. Boissel N, Sender LS. Best practices in adolescent and young adult patients with acute lymphoblastic leukemia: a focus on asparaginase. *J Adolesc Young Adult Oncol.* 2015;4:118-128.
42. Parsons HM, Harlan LC, Seibel NL, Stevens JL, Keegan TH. Clinical trial participation and time to treatment among adolescents and young adults with cancer: does age at diagnosis or insurance make a difference? *J Clin Oncol.* 2011;29:4045-4053.
43. Bleyer A. Young adult oncology: the patients and their survival challenges. *CA Cancer J Clin.* 2007;57:242-255.
44. Albritton K, Barr R, Bleyer A. The adolescence of young adult oncology. *Semin Oncol.* 2009;36:478-488.
45. Armstrong GT, Oeffinger KC, Chen Y, et al. Modifiable risk factors and major cardiac events among adult survivors of childhood cancer. *J Clin Oncol.* 2013;31: 3673-3680.
46. Hudson MM, Ness KK, Gurney JG, et al. Clinical ascertainment of health outcomes among adults treated for childhood cancer. *JAMA.* 2013;309:2371-2381.
47. Castellino SM, Ullrich NJ, Whelen MJ, Lange BJ. Developing interventions for cancer-related cognitive dysfunction in childhood cancer survivors [serial online]. *J Natl Cancer Inst.* 2014;106. pii:dju186.
48. Barton SE, Najita JS, Ginsburg ES, et al. Infertility, infertility treatment, and achievement of pregnancy in female survivors of childhood cancer: a report from the Childhood Cancer Survivor Study cohort. *Lancet Oncol.* 2013;14:873-881.
49. Wasilewski-Masker K, Seidel KD, Leisenring W, et al. Male infertility in long-term survivors of pediatric cancer: a report from the Childhood Cancer Survivor Study. *J Cancer Surviv.* 2014;8:437-447.
50. Barr RD, Ferrari A, Ries L, Whelan J, Bleyer WA. Cancer in adolescents and young adults: a narrative review of the current status and a view of the future [published online ahead of print March 21, 2016]. *JAMA Pediatr.* doi: 10.1002/jamapediatrics.2015.4689.
51. Surveillance, Epidemiology, and End Results (SEER) Program. SEER-Medicare linked database 2006–2010. Bethesda, MD: National Cancer Institute, Division of Cancer Control and Population Sciences, Applied Research Program, Health Services and Economics Branch; 2013.
52. Gamelin E, Gamelin L, Bossi L, Quasthoff S. Clinical aspects and molecular basis of oxaliplatin neurotoxicity: current management and development of preventive measures. *Semin Oncol.* 2002;29:21-33.
53. Ramsey SD, Berry K, Moinpour C, Giedzinska A, Andersen MR. Quality of life in long term survivors of colorectal cancer. *Am J Gastroenterol.* 2002;97:1228-1234.
54. Emmertsen KJ, Laurberg S; Rectal Cancer Function Study Group. Impact of bowel dysfunction on quality of life after sphincter-preserving resection for rectal cancer. *Br J Surg.* 2013;100:1377-1387.
55. Lange MM, Martz JE, Ramdeen B, et al. Long-term results of rectal cancer surgery with a systematical operative approach. *Ann Surg Oncol.* 2013;20:1806-1815.
56. Den Oudsten BL, Traa MJ, Thong MS, et al. Higher prevalence of sexual dysfunction in colon and rectal cancer survivors compared with the normative population: a population-based study. *Eur J Cancer.* 2012;48:3161-3170.
57. Liu L, Herrinton LJ, Hornbrook MC, Wendel CS, Grant M, Krouse RS. Early and late complications among long-term colorectal cancer survivors with ostomy or anastomosis. *Dis Colon Rectum.* 2010;53: 200-212.
58. El-Shami K, Oeffinger KC, Erb NL, et al. American Cancer Society Colorectal Cancer Survivorship Care Guidelines. *CA Cancer J Clin.* 2015;65:427-455.
59. Primrose JN, Perera R, Gray A, et al. Effect of 3 to 5 years of scheduled CEA and CT follow-up to detect recurrence of colorectal cancer: the FACS randomized clinical trial. *JAMA.* 2014;311:263-270.
60. Tjandra JJ, Chan MK. Follow-up after curative resection of colorectal cancer: a meta-analysis. *Dis Colon Rectum.* 2007;50: 1783-1799.
61. Mariotto AB, Rowland JH, Ries LA, Scoppa S, Feuer EJ. Multiple cancer prevalence: a growing challenge in long-term survivorship. *Cancer Epidemiol Biomarkers Prev.* 2007;16:566-571.
62. Surveillance, Epidemiology and End Results (SEER) Program. SEER*Stat Database: North American Association of Central Cancer Registries (NAACCR) Incidence-CiNA Analytic File, 1995–2012, for NHIAv2 Origin, Custom File With County, ACS Facts & Figures Projection Project, NAACCR. Bethesda, MD: National Cancer Institute, Division of Cancer Control and Population Sciences, Surveillance Research Program, Cancer Statistics Branch; 2015.
63. Dohner H, Estey EH, Amadori S, et al. Diagnosis and management of acute myeloid leukemia in adults: recommendations from an international expert panel, on behalf of the European LeukemiaNet. *Blood.* 2010;115:453-474.
64. Dohner H, Weisdorf DJ, Bloomfield CD. Acute myeloid leukemia. *N Engl J Med.* 2015;373:1136-1152.
65. Ferdinand R, Mitchell SA, Batson S, Tumur I. Treatments for chronic myeloid leukemia: a qualitative systematic review. *J Blood Med.* 2012;3:51-76.
66. Faderl S, Jeha S, Kantarjian HM. The biology and therapy of adult acute lympho-

blastic leukemia. *Cancer.* 2003;98:1337-1354.

67. Moorman AV, Harrison CJ, Buck GA, et al. Karyotype is an independent prognostic factor in adult acute lymphoblastic leukemia (ALL): analysis of cytogenetic data from patients treated on the Medical Research Council (MRC) UKALLXII/Eastern Cooperative Oncology Group (ECOG) 2993 trial. *Blood.* 2007;109:3189-3197.
68. Inaba H, Greaves M, Mullighan CG. Acute lymphoblastic leukaemia. *Lancet.* 2013; 381:1943-1955.
69. Burger JA, Tedeschi A, Barr PM, et al. Ibrutinib as initial therapy for patients with chronic lymphocytic leukemia. *N Engl J Med.* 2015;373:2425-2437.
70. Goede V, Fischer K, Busch R, et al. Obinutuzumab plus chlorambucil in patients with CLL and coexisting conditions. *N Engl J Med.* 2014;370:1101-1110.
71. Hillmen P, Robak T, Janssens A, et al. Chlorambucil plus ofatumumab versus chlorambucil alone in previously untreated patients with chronic lymphocytic leukaemia (COMPLEMENT 1): a randomised, multicentre, open-label phase 3 trial. *Lancet.* 2015;385:1873-1883.
72. Jain P, O'Brien S. Richter's transformation in chronic lymphocytic leukemia. *Oncology (Williston Park).* 2012;26:1146-1152.
73. Tsai HK, Mauch PM. Nodular lymphocyte-predominant Hodgkin lymphoma. *Semin Radiat Oncol.* 2007;17:184-189.
74. Miller TP, Dahlberg S, Cassady JR, et al. Chemotherapy alone compared with chemotherapy plus radiotherapy for localized intermediate- and high-grade non-Hodgkin's lymphoma. *N Engl J Med.* 1998;339:21-26.
75. Coiffier B. State-of-the-art therapeutics: diffuse large B-cell lymphoma. *J Clin Oncol.* 2005;23:6387-6393.
76. Shankland KR, Armitage JO, Hancock BW. Non-Hodgkin lymphoma. *Lancet.* 2012;380:848-857.
77. Pui CH, Robison LL, Look AT. Acute lymphoblastic leukaemia. *Lancet.* 2008;371: 1030-1043.
78. Poghosyan H, Sheldon LK, Leveille SG, Cooley ME. Health-related quality of life after surgical treatment in patients with non-small cell lung cancer: a systematic review. *Lung Cancer.* 2013;81:11-26.
79. Chambers SK, Dunn J, Occhipinti S, et al. A systematic review of the impact of stigma and nihilism on lung cancer outcomes [serial online]. *BMC Cancer.* 2012; 12:184.
80. Karam-Hage M, Cinciripini PM, Gritz ER. Tobacco use and cessation for cancer survivors: an overview for clinicians. *CA Cancer J Clin.* 2014;64:272-290.
81. Sitas F, Weber MF, Egger S, Yap S, Chiew M, O'Connell D. Smoking cessation after cancer. *J Clin Oncol.* 2014;32: 3593-3595.
82. Karimkhani C, Gonzalez R, Dellavalle RP. A review of novel therapies for melanoma. *Am J Clin Dermatol.* 2014;15:323-337.
83. Larkin J, Chiarion-Sileni V, Gonzalez R, et al. Combined nivolumab and ipilimumab or monotherapy in untreated melanoma. *N Engl J Med.* 2015;373:23-34.
84. Robert C, Schachter J, Long GV, et al. Pembrolizumab versus ipilimumab in advanced melanoma. *N Engl J Med.* 2015; 372:2521-2532.
85. Davies H, Bignell GR, Cox C, et al. Mutations of the BRAF gene in human cancer. *Nature.* 2002;417:949-954.
86. Jang S, Atkins MB. Which drug, and when, for patients with BRAF-mutant melanoma? *Lancet Oncol.* 2013;14:e60-69.
87. Chapman PB, Hauschild A, Robert C, et al. Improved survival with vemurafenib in melanoma with BRAF V600E mutation. *N Engl J Med.* 2011;364:2507-2516.
88. Balamurugan A, Rees JR, Kosary C, Rim SH, Li J, Stewart SL. Subsequent primary cancers among men and women with in situ and invasive melanoma of the skin. *J Am Acad Dermatol.* 2011;65:S69-S77.
89. Hodi FS, O'Day SJ, McDermott DF, et al. Improved survival with ipilimumab in patients with metastatic melanoma. *N Engl J Med.* 2010;363:711-723.
90. Smith RA, Andrews K, Brooks D, et al. Cancer screening in the United States, 2016: a review of current American Cancer Society guidelines and current issues in cancer screening. *CA Cancer J Clin.* 2016;66:95-114.
91. Albertsen PC, Hanley JA, Fine J. 20-year outcomes following conservative management of clinically localized prostate cancer. *JAMA.* 2005;293:2095-2101.
92. Lu-Yao GL, Albertsen PC, Moore DF, et al. Outcomes of localized prostate cancer following conservative management. *JAMA.* 2009;302:1202-1209.
93. Shappley WV 3rd, Kenfield SA, Kasperzyk JL, et al. Prospective study of determinants and outcomes of deferred treatment or watchful waiting among men with prostate cancer in a nationwide cohort. *J Clin Oncol.* 2009;27:4980-4985.
94. Ryan CJ, Smith MR, de Bono JS, et al. Abiraterone in metastatic prostate cancer without previous chemotherapy. *N Engl J Med.* 2013;368:138-148.
95. de Bono JS, Logothetis CJ, Molina A, et al. Abiraterone and increased survival in metastatic prostate cancer. *N Engl J Med.* 2011;364:1995-2005.
96. Beer TM, Armstrong AJ, Rathkopf DE, et al. Enzalutamide in metastatic prostate cancer before chemotherapy. *N Engl J Med.* 2014;371:424-433.
97. Scher HI, Fizazi K, Saad F, et al. Increased survival with enzalutamide in prostate cancer after chemotherapy. *N Engl J Med.* 2012;367:1187-1197.
98. Birkhahn M, Penson DF, Cai J, et al. Long-term outcome in patients with a Gleason score $\leq$ 6 prostate cancer treated by radical prostatectomy. *BJU Int.* 2011;108:660-664.
99. Nam RK, Cheung P, Herschorn S, et al. Incidence of complications other than urinary incontinence or erectile dysfunction after radical prostatectomy or radiotherapy for prostate cancer: a population-based cohort study. *Lancet Oncol.* 2014; 15:223-231.
100. Alicikus ZA, Yamada Y, Zhang Z, et al. Ten-year outcomes of high-dose, intensity-modulated radiotherapy for localized prostate cancer. *Cancer.* 2011;117:1429-1437.
101. Resnick MJ, Koyama T, Fan KH, et al. Long-term functional outcomes after treatment for localized prostate cancer. *N Engl J Med.* 2013;368:436-445.
102. Taylor KL, Luta G, Miller AB, et al. Long-term disease-specific functioning among prostate cancer survivors and noncancer controls in the prostate, lung, colorectal, and ovarian cancer screening trial. *J Clin Oncol.* 2012;30:2768-2775.
103. Alibhai SM, Duong-Hua M, Sutradhar R, et al. Impact of androgen deprivation therapy on cardiovascular disease and diabetes. *J Clin Oncol.* 2009;27:3452-3458.
104. Saylor PJ, Smith MR. Metabolic complications of androgen deprivation therapy for prostate cancer. *J Urol.* 2013;189:S34-S42; discussion S43–S34.
105. Keating NL, O'Malley AJ, Freedland SJ, Smith MR. Diabetes and cardiovascular disease during androgen deprivation therapy: observational study of veterans with prostate cancer. *J Natl Cancer Inst.* 2010; 102:39-46.
106. Wadhwa VK, Weston R, Mistry R, Parr NJ. Long-term changes in bone mineral density and predicted fracture risk in patients receiving androgen-deprivation therapy for prostate cancer, with stratification of treatment based on presenting values. *BJU Int.* 2009;104:800-805.
107. Nguyen PL, Je Y, Schutz FA, et al. Association of androgen deprivation therapy with cardiovascular death in patients with prostate cancer: a meta-analysis of randomized trials. *JAMA.* 2011;306:2359-2366.
108. Levine GN, D'Amico AV, Berger P, et al. Androgen-deprivation therapy in prostate cancer and cardiovascular risk: a science advisory from the American Heart Association, American Cancer Society, and American Urological Association: endorsed by the American Society for Radiation Oncology. *CA Cancer J Clin.* 2010;60:194-201.
109. Skolarus TA, Wolf AM, Erb NL, et al. American Cancer Society prostate cancer survivorship care guidelines. *CA Cancer J Clin.* 2014;64:225-249.
110. Leung E, Warde P, Jewett M, et al. Treatment burden in stage I seminoma: a comparison of surveillance and adjuvant radiation therapy. *BJU Int.* 2013;112:1088-1095.
111. Willemse PM, Burggraaf J, Hamdy NA, et al. Prevalence of the metabolic syndrome and cardiovascular disease risk in chemotherapy-treated testicular germ cell tumour survivors. *Br J Cancer.* 2013;109: 60-67.
112. Torre LA, Siegel RL, Ward EM, Jemal A. Global Cancer Incidence and Mortality Rates and Trends-An Update. *Cancer Epidemiol Biomarkers Prev.* 2016;25:16-27.
113. Davies L, Morris LG, Haymart M, et al. American Association of Clinical Endocrinologists and American College of Endocrinology disease state clinical review: the increasing incidence of thyroid cancer. *Endocr Pract.* 2015;21:686-696.
114. Morris LG, Tuttle RM, Davies L. Changing trends in the incidence of thyroid cancer in the United States. *JAMA Otolaryngol Head Neck Surg.* 2016 April 14; [Epub ahead of print].

115. Chen AY, Jemal A, Ward EM. Increasing incidence of differentiated thyroid cancer in the United States, 1988-2005. *Cancer*. 2009;115:3801-3807.

116. Schmid D, Ricci C, Behrens G, Leitzmann MF. Adiposity and risk of thyroid cancer: a systematic review and meta-analysis. *Obes Rev*. 2015;16:1042-1054.

117. Pitt SC, Moley JF. Medullary, anaplastic, and metastatic cancers of the thyroid. *Semin Oncol*. 2010;37:567-579.

118. Haymart MR, Banerjee M, Stewart AK, Koenig RJ, Birkmeyer JD, Griggs JJ. Use of radioactive iodine for thyroid cancer. *JAMA*. 2011;306:721-728.

119. Iyer NG, Morris LG, Tuttle RM, Shaha AR, Ganly I. Rising incidence of second cancers in patients with low-risk (T1N0) thyroid cancer who receive radioactive iodine therapy. *Cancer*. 2011;117:4439-4446.

120. Santoro M, Carlomagno F. Central role of RET in thyroid cancer [serial online]. *Cold Spring Harb Perspect Biol*. 2013;5:a009233.

121. Cheung G, Sahai A, Billia M, Dasgupta P, Khan MS. Recent advances in the diagnosis and treatment of bladder cancer [serial online]. *BMC Med*. 2013;11:13.

122. Efstathiou JA, Spiegel DY, Shipley WU, et al. Long-term outcomes of selective bladder preservation by combined-modality therapy for invasive bladder cancer: the MGH experience. *Eur Urol*. 2012; 61:705-711.

123. Mitin T, Hunt D, Shipley WU, et al. Transurethral surgery and twice-daily radiation plus paclitaxel-cisplatin or fluorouracil-cisplatin with selective bladder preservation and adjuvant chemotherapy for patients with muscle invasive bladder cancer (RTOG 0233): a randomised multicentre phase 2 trial. *Lancet Oncol*. 2013; 14:863-872.

124. Heney NM, Ahmed S, Flanagan MJ, et al. Superficial bladder cancer: progression and recurrence. *J Urol*. 1983;130:1083-1086.

125. Lutzeyer W, Rubben H, Dahm H. Prognostic parameters in superficial bladder cancer: an analysis of 315 cases. *J Urol*. 1982; 127:250-252.

126. Lee RK, Abol-Enein H, Artibani W, et al. Urinary diversion after radical cystectomy for bladder cancer: options, patient selection, and outcomes. *BJU Int*. 2014;113:11-23.

127. Roghmann F, Becker A, Trinh QD, et al. Updated assessment of neobladder utilization and morbidity according to urinary diversion after radical cystectomy: a contemporary US-population-based cohort. *Can Urol Assoc J*. 2013;7:E552-E560.

128. Audette C, Waterman J. The sexual health of women after gynecologic malignancy. *J Midwifery Womens Health*. 2010;55:357-362.

129. Tada H, Teramukai S, Fukushima M, Sasaki H. Risk factors for lower limb lymphedema after lymph node dissection in patients with ovarian and uterine carcinoma [serial online]. *BMC Cancer*. 2009;9:47.

130. Kent EE, Ambs A, Mitchell SA, Clauser SB, Smith AW, Hays RD. Health-related quality of life in older adult survivors of selected cancers: data from the SEER-MHOS linkage. *Cancer*. 2015;121:758-765.

131. Koch L, Jansen L, Brenner H, Arndt V. Fear of recurrence and disease progression in long-term (≥5 years) cancer survivors—a systematic review of quantitative studies. *Psychooncology*. 2013;22:1-11.

132. Kim Y, Kashy DA, Spillers RL, Evans TV. Needs assessment of family caregivers of cancer survivors: three cohorts comparison. *Psychooncology*. 2010;19: 573-582.

133. Demark-Wahnefried W, Rogers LQ, Alfano CM, et al. Practical clinical interventions for diet, physical activity, and weight control in cancer survivors. *CA Cancer J Clin*. 2015;65:167-189.

134. Westmaas JL, Alcaraz KI, Berg CJ, Stein KD. Prevalence and correlates of smoking and cessation-related behavior among survivors of ten cancers: findings from a nationwide survey nine years after diagnosis. *Cancer Epidemiol Biomarkers Prev*. 2014;23:1783-1792.

135. National Cancer Institute, National Institutes of Health, US Department of Health and Human Services. Cancer Trends Progress Report. Bethesda, MD: National Cancer Institute, National Institutes of Health, US Department of Health and Human Services; 2015. progressreport.cancer.gov. Accessed January 6, 2016.

136. American College of Surgeons. Cancer program standards 2016: ensuring patient-centered care. facs.org/quality%20programs/cancer/coc/standards. Accessed December 30, 2015.

137. Alliance for Quality Psychosocial Cancer Care. A Resource Guide for CoC-Accredited Facilities: Meeting the Commission on Cancer Patient-Centered Standards. cfah.org/pdfs/Alliance_Resource_Guide_for_CoC_Patient_Centered_Standards_February2015.pdf. Accessed December 30, 2015.

138. Cohen EEW, LaMonte SJ, Erb NL, et al. American Cancer Society head and neck cancer survivorship care guideline [published online ahead of print March 22, 2016]. *CA Cancer J Clin*. doi: 10.3322/caac.21343.