Cost of Care for Elderly Cancer Patients in the United States

K. Robin Yabroff, Elizabeth B. Lamont, Angela Mariotto, Joan L. Warren, Marie Topor, Angela Meekins, Martin L. Brown

Background Timely estimates of the costs of care for cancer patients are an important element in the formulation of national cancer programs and policies. We estimated net costs of care for elderly cancer patients in the United States for the 18 most prevalent cancers and for all other tumor sites combined.

Methods We used Surveillance, Epidemiology, and End Results–Medicare files to identify 718907 cancer patients and 1623651 noncancer control subjects. Within each tumor site, noncancer control subjects were matched to patients by sex, age group, geographic location, and phase of care (ie, initial, continuing, and last year of life). Costs of care were estimated for each phase by use of Medicare claims data from January 1, 1999, through December 31, 2003. Per-patient net costs of care were applied to the 5-year survival of cancer patients by phase of care to estimate 5-year costs of care and extrapolated to the elderly US Medicare population diagnosed with cancer in 2004.

Results Across tumor sites, mean net costs of care were highest in the initial and last year of life phases of care and lowest in the continuing phase. Mean 5-year net costs varied widely, from less than $20000 for patients with breast cancer or melanoma of the skin to more than $40000 for patients with brain or other nervous system, esophageal, gastric, or ovarian cancers or lymphoma. For elderly cancer patients diagnosed in 2004, aggregate 5-year net costs of care to Medicare were estimated to be approximately $21.1 billion. Costs to Medicare were highest for lung, colorectal, and prostate cancers, reflecting underlying incidence, stage distribution at diagnosis, survival, and phase-specific costs for these tumor sites.

Conclusions The costs of cancer care to Medicare are substantial and vary by tumor site, phase of care, stage at diagnosis, and survival.

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In 2003, approximately 10 million Americans were alive with a history of cancer (1). Cancer prevalence is expected to increase because the US population is growing and aging and cancer incidence increases with age (1,2). On the basis of projections from the best currently available estimates, approximately $72.1 billion was spent on cancer care in 2004 alone (3). Costs of cancer care are likely to increase in the future with expected increases in cancer prevalence.

A recent review of studies of the costs of cancer care in the United States found heterogeneity across the studies in the settings, populations studied, types of services included, measurement of costs, and study methods (4). The variability in methods across these studies complicates comparisons of costs of cancer care across tumor sites. Although several studies included in the review assessed the cost of care in multiple tumor sites (5–10), many used tumor registries to identify incident cancer patients diagnosed from the late 1980s to the early 1990s (5–8). Practice patterns in oncology have changed since the early 1990s, indicating the need for updated estimates of the cost of cancer care in the United States.

Several approaches have been used to estimate costs of cancer care, including incidence, prevalence, and phase of care approaches (5–7,9–11). The phase of care approach divides care into clinically relevant periods—the initial period after diagnosis, the last year of life, and the intervening or continuing period—and has the advantage of allowing estimation of long-term costs of care when applied to survival life tables. In this study, we estimated the cost of cancer care for the 18 most prevalent cancers as well as all remaining tumor sites combined by phase of care by use of more recent population-based incidence, cost, and survival data. We then estimated long-term costs of cancer care and applied these estimates to the elderly US Medicare

Affiliations of authors: Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD (KRY, A. Mariotto, JLW, MLB); Department of Health Care Policy, Massachusetts General Hospital Cancer Center and Harvard Medical School, Boston, MA (EBL); Information Management Systems, Inc, Rockville, MD (MT, A. Meekins).

Correspondence to: K. Robin Yabroff, PhD, MBA, Health Services and Economics Branch/Applied Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, Executive Plaza North, Rm 4005, 6130 Executive Blvd, MSC 7344, Bethesda, MD 20892-7344 (e-mail: yabroffr@mail.nih.gov).

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population that is diagnosed with cancer in a single year. To our knowledge, this is the only study to combine current cost estimates with survival data for multiple tumor sites to develop aggregate long-term Medicare cost estimates. Because the majority of cancer patients are elderly (1), these estimates may be particularly useful to the Centers for Medicare and Medicaid Services in their cancer-related policy and coverage planning.

CONTEXT AND CAVEATS

Prior knowledge

Timely estimates of the costs of care for cancer patients are an important element in the formulation of national cancer programs and policies.

Study design

Population-based study in which data from Surveillance, Epidemiology and End Results (SEER)–Medicare claims files were used to estimate net costs of care by phase of care (i.e., initial, continuing, and last year of life) from January 1, 1999, through December 31, 2003. These costs were then applied to survival data to estimate 5-year costs of care and extrapolated to newly diagnosed elderly cancer patients in 2004.

Contribution

The costs of cancer care to Medicare are substantial and vary by tumor site, phase of care, stage at diagnosis, and survival. Five-year costs to Medicare were highest for lung, colorectal, and prostate cancers.

Implications

These estimates represent a basis for projections of cancer costs that will be particularly important with the growth and aging of the US population.

Limitations

Incidence, survival, and costs of care were estimated from SEER and SEER–Medicare and assumed to be representative of the United States. Geographic variation may not be fully reflected in these estimates. Cost estimates did not include out-of-pocket expenses or co-payments and were based on the approximately 85% of Medicare enrollees in fee-for-service plans.

Participants and Methods

Data Sources

To determine long-term costs of care for elderly cancer patients, we used data from two sources: cancer registry data from the Surveillance, Epidemiology, and End Results (SEER) program maintained by the National Cancer Institute (NCI) and the SEER data linked to Medicare claims data. The SEER registries collect information about all incident cancer patients from certain geographically defined areas. The area covered by SEER has expanded over time, from nine registries in 1975–1991 to 13 registries starting in 1992 and to 17 registries starting in 2000. With the last expansion, the SEER program includes approximately 26% of the US population (1). For each patient, the SEER data contain every occurrence of a primary incident cancer, month and year of diagnosis, cancer site, stage, histology, and vital status, with cause of death for persons who died.

Persons reported to SEER have been matched against Medicare's master enrollment file, and the claims for Medicare-eligible persons with fee-for-service coverage have been extracted. Among persons with a cancer diagnosis in SEER who were aged 65 years or older, 94% have been linked with Medicare enrollment data (12). To facilitate comparisons between Medicare enrollees with cancer and those without, NCI has created a data file that identifies a 5% random sample of Medicare beneficiaries residing in SEER areas with an indicator of whether or not they have a cancer diagnosis listed in SEER. Patient demographic characteristics and vital status were obtained from Medicare enrollment data, and payments were obtained from Medicare claims. All Medicare claims files, including inpatient (Medicare Analysis and Procedure), Hospital Outpatient, Carrier, Hospice, Home Health Agency, and Durable Medical Equipment, were used to estimate costs of care for cancer patients and noncancer control subjects. The SEER–Medicare database was created by NCI and the Centers for Medicare and Medicaid Services, with approval from the institutional review boards of each of the participating SEER registries. The final analytic dataset used for this analysis was stripped of identifiers. A more detailed description of the SEER–Medicare database is available at http://healthservices.cancer.gov/seermedicare/.

Estimates of the Cost of Care for Cancer Patients

Cancer Patient and Control Subject Selection. Cancer patients were classified by tumor site for those with a diagnosis of brain or other nervous system, breast, cervical, colorectal, corpus uteri, esophageal, gastric, head and neck, liver, lung, ovarian, pancreatic, prostate, renal, or urinary bladder cancer or with leukemia, lymphoma, or melanoma of the skin. Cancer patients with all other diagnoses were grouped together. We selected all 1 144 592 patients who were diagnosed between January 1, 1973, and December 31, 2002, and aged 65 years or older at some time between January 1, 1999, and December 31, 2003—the study observation period—from the SEER–Medicare data. All 148 735 cancer patients with a previous cancer diagnosis and all 5392 cancer patients who were identified as having cancer through a death certificate or autopsy were excluded. Histology codes were reviewed by a practicing oncologist to exclude patients with unusual tumor types (n = 46 844; for details, see Supplementary Appendix, available online). Stage of disease at initial diagnosis is reported with the SEER historic staging system to allow comparison of stage distribution across tumor sites and years of diagnosis.

Historically, managed care organizations have not been required to submit claims or encounter data for specific services received by their Medicare enrollees. For months in which patients received coverage through managed care or were covered through fee for service and without both Medicare Part A and Part B, costs of care and months of observation were excluded because these data would not completely capture care received during this period. An additional 224 714 cancer patients were excluded because they were enrolled in managed care for the entire observation period or did not have both Medicare Part A and Part B at any time during the observation period, and so the final cohort included the remaining 718 907 cancer patients.

Potential control subjects were Medicare beneficiaries aged 65 years or older during the observation period of 1999–2003 without any cancer diagnoses recorded by SEER. A total of 1 623 651 control subjects were selected from the 5% random sample of Medicare enrollees and frequency matched to cancer patients by factors associated with cost, including sex, 5-year age

group (65–69, 70–74, 75–79, or ≥80 years), and SEER registry area. We did not match control subjects to cancer patients on level of comorbidity or other endogenous factors that might differentially impact costs in cancer patients and noncancer control subjects. Thus, our estimates reflect the costs of care in cancer patients as they occur in the United States compared with the average Medicare enrollee without cancer. Our estimates may also reflect the cost of managing comorbid conditions that may occur more commonly in cancer patients than in the average control subject.

Phase of Care Definitions. Phase of care definitions were based on previous studies of direct medical costs (5,6,13,14). For cancer patients, months of observation and cost of care between 1999 and 2003 were divided into three clinically relevant phases of care—initial, continuing, and last year of life care—on the basis of the date of service on the Medicare claim in relation to dates of death and diagnosis. Date of death (or its absence) in the Medicare enrollment file through 2004 was used to determine vital status. Patients who did not die during the observation period were censored at December 31, 2003. For cancer patients, cause of death (classified as cancer or noncancer) was identified by use of death certificate information in the SEER database. To minimize misclassification, cancer deaths in cancer patients with a single cancer diagnosis included any tumor site as the underlying cause of death, whereas cancer deaths in cancer patients with more than one cancer diagnosis were required to be tumor site specific (eg, ovarian cancer–specific death in an ovarian cancer patient who was later diagnosed with breast cancer). The initial phase was defined as the first 12 months after diagnosis, the last year of life phase was defined as the final 12 months of life, and the continuing phase was defined as all months between the initial and last year of life phases of care. Not all cancer patients contributed to all phases of care, however. For patients surviving less than 24 months after diagnosis, the final 12 months of observation and costs of care were allocated first to the last year of life phase, consistent with other studies (15). This approach is also consistent with the application of phase-specific cost estimates (eg, last year of life) to crude monthly survival probabilities in this study. The remainder of months of observation and costs were allocated to the initial phase, with no contribution to the continuing phase. For example, a lung cancer patient who died 13 months after diagnosis would contribute the final 12 months to the last year of life phase of care and the first month after diagnosis to the initial phase of care. Patients diagnosed before 1997 who survived beyond 2004 contributed months and costs of care to the continuing phase only. For example, a breast cancer patient diagnosed in January 1993 and surviving beyond 2004 would contribute 60 months during the observation period 1999–2003 to the continuing phase. For each tumor site and each phase of care, average monthly estimates of cost of care were calculated.

Because control subjects did not have a date of cancer diagnosis, they were randomly assigned a "pseudodiagnosis date" that corresponded to the date of diagnosis of one of the pool of cancer patients. Months of observation and costs of care were assigned to either a last year of life phase or a continuing phase in the same manner used with cancer patients. As with cancer patients, average monthly estimates of cost of care were calculated for each phase of care for each group of control subjects.

In addition to frequency matching by sex, 5-year age group, and SEER area stratum, control subjects were also matched to cancer patients by phase of care in up to a ratio of one cancer patient to five control subjects to maximize statistical power by including more control subjects in each stratum. Control subjects in the continuing phase of care were matched to cancer patients in the initial phase and in the continuing phase. Generally, costs of care at the end of life are high, regardless of the cause of death (16). To reflect costs associated specifically with cancer care in the last year of life, cancer patients who died of cancer were matched to continuing control subjects, and cancer patients who died of other causes were matched to last year of life control subjects. Because comparisons were conducted separately for each tumor site, control subjects could be used more than once and matched to different patients with different cancers. The ratio of case patients to control subjects varied by tumor site and phase of care because of sample size limitations in control subjects.

Cost Estimates. All Medicare claims files were used to estimate costs of care for cancer patients and noncancer control subjects. As has been done in other cost of care studies (5,14), we used Medicare payments, rather than billed charges, to reflect costs of care. Charges reflect price setting rather than resource consumption and, as a result, are thought to be a poor proxy of the true economic cost of medical care (17). Payments for Medicare Part A (inpatient services) and Part B (outpatient services) were calculated separately. The Hospital Input Price Index (18) and the Medicare Economic Index (19) were used to adjust for inflation in Medicare Parts A and B estimates, respectively, for the period 1999–2003. We also adjusted for geographic variability in costs of care across SEER registry sites by use of the Capital Geographic Adjustment Factor for Part A and the Geographic Practice Cost Index for Part B (13). All cost estimates are reported in 2004 dollars.

Within each phase of care and for each tumor site, we calculated total costs of care and total months of observation for cancer patients and control subjects. The mean monthly costs of care by phase of care for cancer patients (superscript P) and control subjects (superscript C) are denoted, respectively, as C^{P}_{phase} and C^{C}_{phase}. The mean net monthly cost by phase of care was estimated as the difference in cost for cancer patients and noncancer control subjects, $C_{phase} = C^{P}_{phase} - C^{C}_{phase}$, and its variance was estimated as $\mathrm{Var}(C_{phase}) = \mathrm{Var}(C^{P}_{phase}) + \mathrm{Var}(C^{C}_{phase})$. Confidence intervals (CIs) were calculated by use of the large sample normal approximation to the mean, as has been done in other large SEER–Medicare cost of care studies (15). We also evaluated net costs of care by stage at diagnosis (local, regional, or distant) in the initial and last year of life phases of care.

Mean 5-Year Net Costs of Care for Elderly Cancer Patients

Estimates of mean monthly net costs of care for cancer patients in the initial, continuing, and last year of life phases of care were applied to crude monthly survival probabilities after diagnosis to calculate 5-year net costs of care. We chose the duration of 5 years to reflect recent survival patterns and to make estimates comparable across the 18 tumor sites evaluated separately in this analysis. We identified cancer patients aged 65 years and older who were diagnosed in the period 1998–2004 for each tumor site by use of

the statistical software SEER-Stat version 6.3.5 (20) with the 13-registry SEER data. We included patients who were newly diagnosed with cancer for the 7-year period (1998–2004) to ensure stable estimates for less common tumor sites. Survival was estimated from diagnosis and represents an average across patients diagnosed in these multiple years starting in month 1. Patients with a previous cancer diagnosis were excluded. To estimate 5-year net costs of care, we calculated crude monthly survival probabilities for 72 months because patients who died in the 6th year following diagnosis would have been in their last year of life for some portion of the 5th year following diagnosis.

We calculated crude monthly probabilities of cancer and noncancer deaths and multiplied monthly net cost estimates in the initial, continuing, and last year of life by the proportions of patients surviving and dying of cancer and other causes in each monthly interval. Let P_i^{AD}, P_i^{CD}, and P_i^{OD} be the probability of any death (AD), cancer death (CD), and other cause of death (OD), respectively, in month i after diagnosis, where $P_i^{AD} = P_i^{CD} + P_i^{OD}$. We assumed that all patients were diagnosed in month 1. For patients dying in month i(i = 1,…, 72) after diagnosis, let $Init_i$, $Cont_i$, and LY_i (*LYC* = last year of life, cancer death, and *LYO* = last year of life, other cause of death) denote the number of months during the 5-year period that patients spent in the initial, continuing, and last year of life phases, respectively. When applying mean monthly net costs by phase of care, we assumed that patients died at the end of the month. For example, patients dying at month 30 of cancer have $Init_i$ = 12, $Cont_i$ = 6, and LYC_i = 12, and patients dying at month 64 of other causes have $Init_i$ = 12, $Cont_i$ = 40, and LYO_i = 8. For patients dying in their sixth year after diagnosis (61 ≤ month i < 72), some of the months in their last year of life (and last year of life costs) will occur in the fifth year after diagnosis, as shown in the last example. The net 5-year cost for cancer patients was calculated as

$$C5Y = C_{LYC}\sum_{i=1}^{71} P_i^{CD}\ LY_i + C_{LYO}\sum_{i=1}^{71} P_i^{OD}\ LY_i + C_{cont}\sum_{i=1}^{71} P_i^{AD}\ Cont_i + C_{init}\sum_{i=1}^{71} P_i^{AD}\ Init_i + \left(1 - P_{72}^{AD}\right)\left[12C_{init} + 48\,C_{cont}\right].$$

We also used the lower and upper bound of the 95% confidence interval for phase-specific cost estimates to estimate a range of plausible 5-year net costs of care. This plausible range represents a conservative estimate of the true 95% confidence interval. Costs were discounted at 3% annually.

Aggregate 5-Year Net Costs of Cancer Care in the Elderly Medicare Population

We applied mean 5-year net cost of care estimates to estimates of incidence by tumor site in a single year in the Medicare population aged 65 years and older. Because cost of care and survival were estimated over a range of earlier years, we made the simplifying assumption that these estimates would approximate cost of care and survival for patients diagnosed in 2004. We used the 17-registry SEER data (approximately 26% of the US population) to estimate the number of newly diagnosed elderly cancer patients in 2004. To extrapolate to the total US population of newly diagnosed Medicare enrollees aged 65 years and older in 2004, we divided the number of newly diagnosed cancer patients estimated with the SEER data by 0.26 for each tumor site.

Results

Sample Characteristics

The number of cancer patients and matched control subjects are listed by tumor site and phase of care in Table 1. In the initial phase of care, the largest number of cancer patients had breast, colorectal, or prostate cancer. Although lung cancer incidence was high in men and women during the observation period (21), most patients are diagnosed at advanced stages in which survival is generally short (21), so many newly diagnosed lung cancer patients were classified in the last year of life phase of care. In the last year of life phase of care, the largest number of cancer patients had breast, colorectal, lung, or prostate cancer. In the continuing phase of care, the largest number of cancer patients had breast or prostate cancer, consistent with both the high incidence and long survival (21) for cancers at these tumor sites.

Stage distributions at initial diagnosis are presented in Table 2. More than 10% of patients with esophageal, gastric, lung, ovarian, and pancreatic cancers were initially diagnosed with distant disease. More than two-thirds of the patients with breast, corpus uteri, renal, or urinary bladder cancer or with melanoma of the skin were initially diagnosed with in situ or localized disease. SEER historic staging combines localized and regional prostate cancer into one category. Because SEER historic staging is not used for brain or other nervous system cancers (International Classification of Diseases for Oncology [ICD-O] codes C71.0–C71.4, C71.7–C72.0, C72.3, C72.5, C72.8, C72.9) or lymphoma (any site), patients with these cancers had missing or unknown stage. Also, because of SEER historic staging definitions, all leukemia patients (ICD-O codes C42.0–C42.1 and C42.4) had distant disease at diagnosis.

Net Cost of Care Estimates for Cancer Patients

Mean net costs of care (ie, the difference in costs between cancer patients and control subjects) are presented in Table 3. Across tumor sites, net cost of care estimates were high in the 12 months of the initial and last year of life phases and lowest in the annual continuing care phase and so followed a U-shaped curve. Net cost estimates in the 12 months of the initial phase were highest for brain or other nervous system, esophageal, gastric, liver, ovarian, and pancreatic cancers—all estimates for these sites were greater than $40 000, and they reached as high as $65 409 (95% CI = $56 581 to $74 238) and $69 908 (95% CI = $61 389 to $78 427) in male and female patients, respectively, with brain or other nervous system cancer. In the last year of life, net cost estimates were greater than $40 000 for patients with esophageal, gastric, liver, lung, ovarian, or pancreatic cancer or with leukemia or lymphoma and as high as $80 589 (95% CI = $75 239 to $85 938) and $76 506 (95% CI = $72 048 to $80 965) for male and female patients with brain or other nervous system cancer, respectively. Net cost estimates were less than $20 000 in the 12 months of the initial phase of care for female patients with breast or corpus uteri cancer, all patients with melanoma of the skin and urinary bladder cancer, and male patients with prostate cancer. In the last year of life phase of care, net cost estimates were greater than $20 000 for cancers at all tumor sites, and net cost estimates were greater than $50 000

Table 1. Elderly cancer patients and matched control subjects by tumor site and phase of care during the observation period 1999–2003*

	Initial phase		Continuing phase		Last year of life phase	
Tumor site	**No. of cancer patients**	**No. of control subjects**	**No. of cancer patients**	**No. of control subjects**	**No. of cancer patients**	**No. of control subjects**
Brain and ONS	307	1535	505	2525	1758	8790
Female breast	27456	137280	131018	131018	35906	88406
Cervix	564	2820	13382	66910	3193	15965
Colorectal	22935	114675	82559	247677	38636	127618
Corpus uteri	4379	21895	33416	133664	9410	33420
Esophagus	849	4245	1360	6800	2290	11450
Gastric	1667	8335	3816	19080	4584	22920
Head and neck	3250	16250	15273	76365	7826	39130
Leukemia	2654	13270	7379	36895	6489	32445
Liver	502	2510	609	3045	1767	8835
Lung	10152	50760	19426	97130	32235	154280
Lymphoma	6286	31430	18993	94965	10418	52090
Melanoma of the skin	8436	42180	31366	156830	7581	37905
Ovary	1647	8235	5521	27605	3706	18530
Pancreas	951	4755	962	4810	5257	26285
Prostate	42761	85522	152539	152539	47095	94556
Renal	2677	13385	9831	49155	4509	22545
Urinary bladder	9475	47375	34791	139164	14431	53971
All other tumor sites†	12857	64285	43956	219780	27778	116856

* The initial phase of care is the first 12 months following diagnosis, the last year of life phase is the final 12 months of life, and the continuing phase is all the months between the initial and last year of life phases. Cancer patients and control subjects could contribute to more than one phase of care. Within each tumor site and phase of care, control subjects were matched to case patients in a ratio of up to 5:1 on age, sex, and geographic region strata. Data source was Surveillance, Epidemiology, and End Results program data linked to Medicare claims data. ONS = other nervous system.

† All other tumor sites includes salivary gland, nasopharynx, tonsil, small intestine, anus, intrahepatic bile duct, gallbladder, other biliary, retroperitoneum, peritoneum, omentum and mesentery, other digestive organs, nose, nasal cavity, middle ear, larynx, pleura, trachea, mediastinum and other respiratory organs, bones and joints, soft tissue, other nonepithelial skin, vagina, vulva, other female genital organs, penis, other male genital organs, ureter, other urinary organs, eye and orbit, thyroid, other endocrine multiple myeloma, and miscellaneous.

for brain or other nervous system, esophageal, gastric, liver, lung, ovarian, and pancreatic cancers and for leukemia and lymphoma.

For most tumor sites and phases of care, confidence intervals for net costs overlapped among men and women. Exceptions were colorectal and head and neck cancers in the continuing and last

Table 2. Stage distribution at diagnosis in elderly cancer patients: initial phase of care (1999–2003)*

			SEER historic stage				
Tumor site	**ICD-O site code(s)**	**No. of patients**	**% in situ**	**% localized**	**% regional**	**% distant**	**% missing or unknown**
Female breast	C50.0–C50.6, C50.8–C50.9	27456	11.6	61.4	22.6	3.3	1.2
Cervix	C53.0–C53.1, C53.8–C53.9	564	0.0	45.6	44.0	6.7	3.7
Colorectal	C18.0, C18.2–C18.9, C19.9, C20.9, C26.0	22935	5.8	45.5	38.9	7.2	2.6
Corpus uteri	C54.0–C54.3, C54.8–C54.9, C55.9	4379	1.4	75.7	15.5	4.0	3.4
Esophagus	C15.0–C15.5, C15.8, C15.9	849	3.4	41.0	30.9	13.2	11.5
Gastric	C16.0–C16.6, C16.8–C16.9	1667	2.1	39.5	38.7	11.3	8.4
Head and neck	C00.0–C06.9, C10.0–C10.9, C12.9–C14.8, C30.0–C32.9	3250	7.0	50.3	35.1	4.4	3.2
Liver	C22.0	502	0.0	61.8	24.1	5.2	9.0
Lung	C34.0–C34.3, C34.8–C34.9	10152	0.1	35.7	40.8	16.9	6.5
Melanoma of the skin	C44.0–C44.9	8436	45.4	44.4	8.1	1.0	1.1
Ovary	C56.9	1647	0.1	13.1	7.2	74.7	4.9
Pancreas	C25.0–C25.4, C25.7–C25.9	951	0.6	13.4	48.6	26.3	11.1
Prostate	C61.9	42761	0.0	93.1		3.6	3.3
Renal	C64.9	2677	0.0	67.9	19.8	8.9	3.5
Urinary bladder	C67.0–C67.9	9475	0.0	82.8	14.5	0.9	1.8

* Stage data are reported by use of Surveillance, Epidemiology, and End Results (SEER) historic staging system to allow comparison of stage distribution across tumor sites. SEER historic staging combines localized and regional prostate cancer into one category. SEER historic staging is not used for brain or other nervous system cancers (ICD-0 codes C71.0–C71.4, C71.7–C72.0, C72.3, C72.5, C72.8, C72.9) or lymphoma (any site). Under SEER historic staging, all leukemia patients (C42.0–C42.1, C42.4) had distant disease at diagnosis. Data source was SEER program data linked to Medicare claims data. ICD-O = International Classification of Diseases for Oncology.

Table 3. Mean net costs of care by phase of care and tumor site in elderly cancer patients*

Tumor site	Phase, estimated cost (95% CI)		
	Initial (12 mo)	Continuing (annual)	Last year of life (12 mo)
Men			
Brain and ONS	$65 409 ($56 581 to $74 238)	$6434 ($3966 to $8902)	$80 589 ($75 240 to $85 939)
Colorectal	$29 609 ($28 949 to $30 268)	$2254 ($2132 to $2377)	$36 483 ($35 742 to $37 224)
Esophagus	$49 811 ($45 429 to $54 193)	$3102 ($2286 to $3919)	$58 208 ($54 471 to $61 945)
Gastric	$46 501 ($43 332 to $49 669)	$1937 ($1434 to $2439)	$54 947 ($52 565 to $57 330)
Head and neck	$21 754 ($20 226 to $23 281)	$2115 ($1891 to $2339)	$32 398 ($30 922 to $33 874)
Leukemia	$24 071 ($21 475 to $26 667)	$5,040 ($4,554 to $5,526)	$61 854 ($59 411 to $64 298)
Liver	$41 284 ($35 323 to $47 244)	$5456 ($3664 to $7248)	$50 917 ($47 179 to $54 656)
Lung	$35 672 ($34 501 to $36 843)	$3926 ($3633 to $4219)	$51 756 ($50 890 to $52 622)
Lymphoma	$28 882 ($27 543 to $30 221)	$4536 ($4220 to $4851)	$51 763 ($50 090 to $53 435)
Melanoma of the skin	$3174 ($2750 to $3598)	$1147 ($996 to $1298)	$22 781 ($21 527 to $24 034)
Pancreas	$57 819 ($52 538 to $63 100)	$4656 ($3214 to $6097)	$65 576 ($62 776 to $68 376)
Prostate	$10 612 ($10 442 to $10 782)	$2134 ($2062 to $2205)	$33 691 ($33 265 to $34 117)
Renal	$27 000 ($25 330 to $28 669)	$3436 ($3071 to $3802)	$38 126 ($36 084 to $40 168)
Urinary bladder	$13 115 ($12 542 to $13 687)	$2813 ($2664 to $2961)	$31 695 ($30 751 to $32 639)
All other tumor sites	$23 661 ($22 767 to $24 555)	$3088 ($2911 to $3265)	$44 381 ($43 379 to $45 383)
Women			
Brain and ONS	$69 908 ($61 389 to $78 427)	$3441 ($1924 to $4957)	$76 507 ($72 049 to $80 965)
Breast	$11 728 ($11 513 to $11 943)	$1201 ($1131 to $1271)	$29 199 ($28 767 to $29 631)
Cervix	$26 302 ($23 962 to $28 643)	$831 ($647 to $1015)	$28 264 ($26 525 to $30 003)
Colorectal	$29 930 ($29 381 to $30 480)	$1595 ($1486 to $1704)	$33 610 ($32 949 to $34 271)
Corpus uteri	$16 268 ($15 597 to $16 939)	$916 ($810 to $1023)	$24 651 ($23 769 to $25 532)
Esophagus	$45 735 ($39 070 to $52 400)	$4151 ($2337 to $5965)	$56 661 ($51 782 to $61 541)
Gastric	$45 785 ($42 115 to $49 454)	$2005 ($1401 to $2610)	$52 877 ($50 205 to $55 549)
Head and neck	$22 048 ($19 953 to $24 143)	$2745 ($2368 to $3121)	$36 983 ($34 878 to $39 088)
Leukemia	$22 607 ($20 045 to $25 169)	$4352 ($3843 to $4860)	$61 277 ($58 624 to $63 929)
Liver	$38 847 ($30 948 to $46 745)	$6580 ($4173 to $8988)	$58 076 ($52 759 to $63 394)
Lung	$34 828 ($33 893 to $35 763)	$3862 ($3584 to $4141)	$50 824 ($49 932 to $51 717)
Lymphoma	$27 686 ($26 431 to $28 941)	$3993 ($3719 to $4266)	$45 760 ($44 356 to $47 163)
Melanoma of the skin	$2928 ($2444 to $3412)	$464 ($298 to $629)	$19 643 ($18 203 to $21 083)
Ovary	$51 548 ($49 366 to $53 732)	$3892 ($3536 to $4248)	$50 154 ($48 405 to $51 902)
Pancreas	$57 176 ($52 686 to $61 666)	$3511 ($2243 to $4779)	$65 852 ($63 509 to $68 195)
Renal	$27 408 ($25 681 to $29 135)	$3540 ($3117 to $3962)	$37 020 ($34 717 to $39 323)
Urinary bladder	$13 122 ($12 144 to $14 100)	$1929 ($1691 to $2167)	$30 669 ($29 214 to $32 125)
All other tumor sites	$23 911 ($23 116 to $24 706)	$2787 ($2617 to $2957)	$45 424 ($44 498 to $46 350)

* The initial phase of care is the first 12 months following diagnosis, the last year of life phase is the final 12 months of life, and the continuing phase is all the months between the initial and last year of life phases. Net costs in the continuing phase of care are an annual estimate. Net costs in the last year of life combines the cost for cancer patients dying of cancer and those dying of other causes. All estimates are in 2004 dollars. Data source was Surveillance, Epidemiology, and End Results program data linked to Medicare claims data. CI = confidence interval; ONS = other nervous system.

year of life phases, melanoma of the skin, and urinary bladder cancer in the continuing phase, and lymphoma in the last year of life phase. In these tumor sites, net costs were generally slightly higher for men than for women.

Hospitalization was the single largest component of net costs for patients with cancers at most tumor sites in the initial phase of care (Figure 1). Exceptions included female patients with breast cancer, all patients with lymphoma or melanoma of the skin, and male patients with prostate cancer. Hospitalization costs accounted for at least 60% of the net costs in the last year of life for all tumor sites (Figure 2). The relative contribution of hospitalization costs to net costs was more variable in the continuing phase of care (data not shown).

Stage at Diagnosis and Net Costs of Care by Phase

In general, net costs in the initial phase of care were higher with later stage at diagnosis (Table 4). For example, net costs of colorectal cancer care were $24 221 (95% CI = $23 666 to $24 775) among patients diagnosed with local disease, $35 981 (95% CI = $35 270 to $36 692) among those diagnosed with regional disease, and $51 158 (95% CI = $49 157 to $53 159) among those diagnosed with distant disease. For female breast, colorectal, corpus uteri, head and neck, ovarian, and urinary bladder cancers, net costs in the initial phase of care among patients diagnosed with distant disease were approximately double those for patients diagnosed with local disease. For esophageal and pancreatic cancers, net cost estimates were more similar across disease stage, with overlapping confidence intervals.

Net costs of care in the last year of life phase of care were generally higher with later stage at diagnosis. For example, net costs of care for colorectal cancer patients in the last year of life were $28 958 (95% CI = $28 173 to $29 743) among those who were originally diagnosed with localized disease, $34 425 (95% CI = $33 645 to $35 205) among those diagnosed with regional disease, and $57 806 (95% CI = $56 307 to $59 304) among those diagnosed with distant disease. For cervical, colorectal, corpus uteri, head and neck, ovarian, and urinary bladder cancers and melanoma of the skin, net costs of care in the last year of life phase among patients diagnosed with distant disease were approximately double

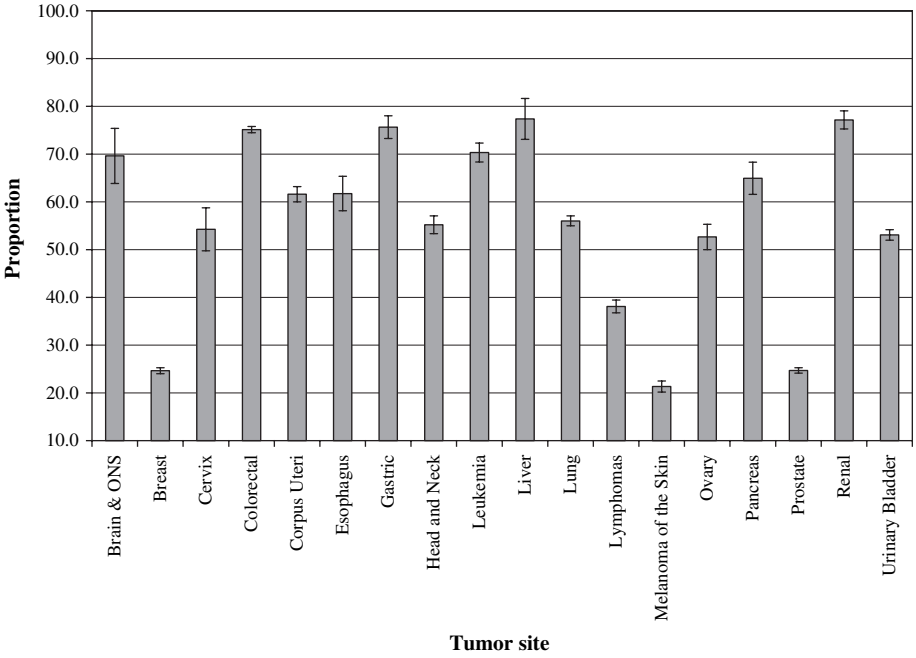

Figure 1. Proportion of net costs from hospitalizations in the initial phase of care. The initial phase of care is the first 12 months after diagnosis. ONS = other nervous system. **Error bars** are 95% confidence intervals. Data source was Surveillance, Epidemiology, and End Results program data linked to Medicare claims data.

those for patients diagnosed with local disease. For esophageal and liver cancers, net costs were similar by stage at initial diagnosis.

Mean 5-Year Net Costs of Care

Estimates of mean 5-year net costs of care varied widely across tumor sites, reflecting differences in stage distribution at diagnosis and survival and phase-specific differences in costs (Table 5). For every tumor site, year 1 net costs accounted for most of the undiscounted 5-year net costs. Discounted mean 5-year net costs were less than $20 000 for breast and prostate cancers and melanoma of the skin and were greater than $40 000 for brain or other nervous system, esophageal, gastric, and ovarian cancers and for lymphoma. The proportion of cancer patients who were alive 1 year after diagnosis was greater than 85% for breast and prostate cancers and melanoma of the skin but less than 20% for brain or other nervous system and pancreatic cancers.

Aggregate 5-Year Costs of Cancer Care in the Elderly US Medicare Population

When the mean 5-year net costs were applied to the cohort of elderly Medicare cancer patients newly diagnosed in a single year (2004), 5-year aggregate costs of care were $21.1 billion (Table 6). Aggregate costs of care were highest for patients diagnosed with lung cancer ($4.2 billion), colorectal cancer ($3.1 billion), and

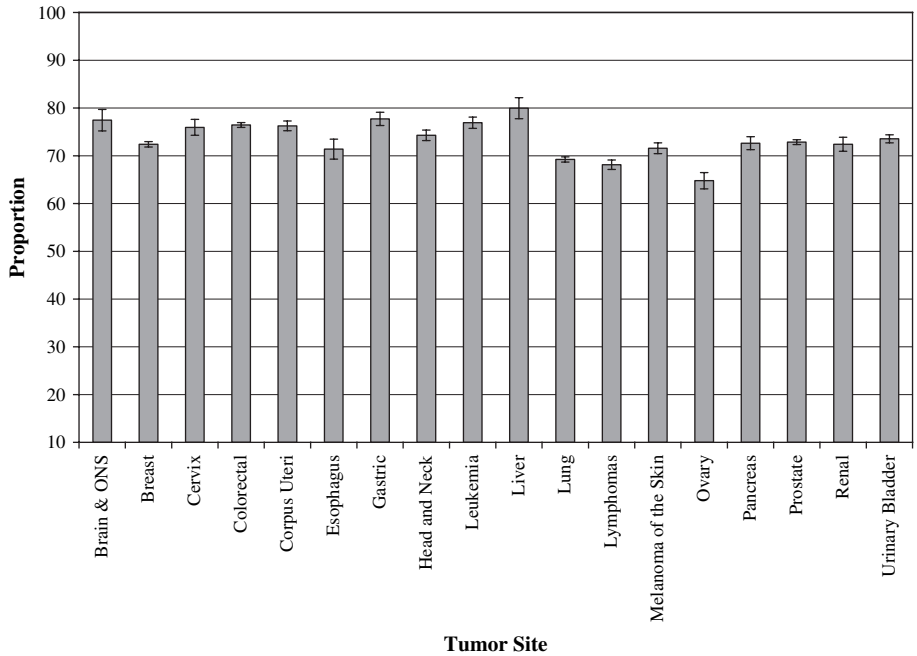

Figure 2. Proportion of net costs from hospitalizations in the last year of life phase. The last year of life phase is the final 12 months of life. Net costs in the last year of life combined the cost for cancer patients dying of cancer and those dying of other causes. ONS = other nervous system. **Error bars** are 95% confidence intervals. Data source was Surveillance, Epidemiology, and End Results program data linked to Medicare claims data.

Table 4. Mean net costs of care in elderly cancer patients by stage at diagnosis, phase of care, and tumor site*

Phase of care	Tumor site	Stage at diagnosis, estimated cost in $ (95% CI)		
		Local	Regional	Distant
Initial (12 mo)	Female breast	9758 (9521 to 9995)	18449 (17913 to 18984)	28493 (26501 to 30485)
	Cervix	19625 (16504 to 22746)	32849 (29311 to 36386)	41201 (29226 to 53176)
	Colorectal	24221 (23666 to 24775)	35981 (35270 to 36692)	51158 (49157 to 53159)
	Corpus uteri	13646 (12980 to 14313)	25351 (23223 to 27479)	42499 (36563 to 48435)
	Esophagus	46752 (41252 to 52252)	59667 (52150 to 67185)	45303 (34380 to 56226)
	Gastric	39241 (35734 to 42748)	57037 (52797 to 61278)	52792 (46015 to 59570)
	Head and neck	11098 (9990 to 12205)	39189 (36481 to 41898)	52148 (43594 to 60701)
	Liver	40742 (34960 to 46525)	38534 (29060 to 48009)	58628 (26812 to 90444)
	Lung	30554 (29442 to 31665)	38917 (37703 to 40130)	42833 (40796 to 44870)
	Melanoma	3211 (2750 to 3672)	10881 (9289 to 12474)	21717 (15704 to 27730)
	Ovary	30288 (26191 to 34385)	41890 (35278 to 48501)	58188 (55535 to 60842)
	Pancreas	53444 (45442 to 61445)	63407 (58592 to 68223)	58762 (51033 to 66491)
	Prostate†	—	10592 (10420 to 10765)	12765 (11543 to 13986)
	Renal	24998 (23656 to 26339)	28173 (25442 to 30904)	43906 (37494 to 50318)
	Urinary bladder	9799 (9334 to 10264)	31642 (29831 to 33452)	51111 (41494 to 60728)
Last year of life (12 mo)	Female breast	26412 (25849 to 26974)	31263 (30455 to 32072)	43850 (41854 to 45845)
	Cervix	26867 (23209 to 30525)	38560 (34329 to 42792)	58439 (48060 to 68819)
	Colorectal	28958 (28173 to 29743)	34425 (33645 to 35205)	57806 (56307 to 59304)
	Corpus uteri	21412 (20423 to 22402)	33595 (30666 to 36524)	44454 (40355 to 48552)
	Esophagus	51274 (44987 to 57560)	61606 (56638 to 66573)	67526 (61987 to 73065)
	Gastric	45301 (41844 to 48758)	52155 (49292 to 55019)	78430 (74416 to 82444)
	Head and neck	27054 (25458 to 28650)	41379 (39205 to 43553)	53129 (46367 to 59891)
	Liver	48511 (44036 to 52986)	55176 (49099 to 61253)	69572 (62014 to 77131)
	Lung	39433 (38169 to 40696)	52727 (51699 to 53755)	66969 (65759 to 68179)
	Melanoma	20145 (18844 to 21446)	26215 (23613 to 28816)	46177 (40374 to 51980)
	Ovary	22732 (19095 to 26369)	38354 (31894 to 44814)	57248 (55101 to 59396)
	Pancreas	55664 (50747 to 60581)	62331 (59241 to 65421)	75229 (72456 to 78001)
	Prostate†	—	33364 (32878 to 33850)	37504 (35948 to 39060)
	Renal	31006 (28965 to 33048)	36814 (33612 to 40016)	54730 (50842 to 58618)
	Urinary bladder	27531 (26626 to 28436)	42202 (40282 to 44122)	67812 (59824 to 75800)

* The initial phase of care is the first 12 months after diagnosis, the last year of life phase is the final 12 months of life, and the continuing phase is all the months between the initial and last year of life phases. Net costs in the last year of life combined the cost for cancer patients dying of cancer and those dying of other causes. All estimates are in 2004 dollars. Data source was Surveillance, Epidemiology, and End Results (SEER) program data linked to Medicare claims data. CI = confidence interval.

† SEER historic staging combines localized and regional prostate cancer into one category. Patients with brain or other nervous system cancer, leukemia, and lymphoma were not included in this table because under SEER historic staging, they were either not staged or all were classified as having distant disease at diagnosis.

prostate cancer ($2.3 billion). Five-year aggregate costs of care were less than $500 million for brain or other nervous system, cervical, corpus uteri, esophageal, head and neck, and liver cancers and for melanoma of the skin.

Discussion

In this study, we used SEER–Medicare and SEER data to estimate net costs of medical care for the 18 most prevalent tumor sites individually as well as all remaining cancers together by phase of care. These phase-specific estimates were then applied to survival probabilities to estimate 5-year net costs of care. When extrapolated to the elderly Medicare patients diagnosed with cancer in 2004, 5-year aggregate costs of cancer care are substantial, approximately $21.1 billion. With expected population growth and aging and increases in life expectancy, the prevalence of cancer will increase, and, as a result, the cost of cancer care to the Medicare program will increase as well.

Disease-specific estimates of direct medical cost are a perennial interest in health economics and health policy (22). At the aggregate level, disease-specific estimates of medical costs can inform resource allocation and fiscal planning (23) and are a necessary element for construction of national health accounts (a comprehensive measure of national health expenditures), which can be used to assess the productivity of health-care delivery within and across countries (24,25). The phase-specific cost estimates presented in this study can also be incorporated into cost-effectiveness models of cancer control strategies, especially those designed to evaluate prevention and screening interventions.

Estimated 5-year aggregate Medicare costs varied by tumor site, reflecting differences in incidence, stage distribution at diagnosis, intensity of treatment, survival, and phase of care–specific costs. Five-year costs of care for lung cancer patients accounted for approximately 20% of the total cost of cancer care to Medicare, at approximately $4.2 billion. Five-year costs to Medicare were estimated to be greater than $2 billion for patients with colorectal or prostate cancer diagnosed in 2004. Further evaluation, prioritization, and implementation of effective cancer control interventions, including those designed to improve prevention, screening, and treatment, may be warranted from a program perspective, given the magnitude of these costs and US population trends. Simulation models, such as those developed through the NCI-sponsored Cancer Intervention Surveillance Modeling Network, can simultaneously incorporate and project the impact of interventions to improve prevention, screening,

Table 5. Mean 5-year net costs of care by tumor site in elderly cancer patients*

Tumor site	% alive after diagnosis		Undiscounted costs, $		5-year discounted costs at 3%, $ (plausible range)
	Year 1	Year 5	Year 1	5-year	
Men					
Brain and ONS	20.2	3.3	40344	48339	47950 (42356–53553)
Colorectal	76.6	46.9	25711	37347	36621 (35466–37772)
Esophagus	40.9	12.3	35972	48452	47810 (43258–52349)
Gastric	42.7	15.7	33425	44792	44203 (41137–47275)
Head and neck	77.2	44.3	21052	31230	30623 (28172–33081)
Leukemia	53.3	25.8	23919	41843	40713 (37423–44001)
Liver	29.8	6.7	24086	34409	33844 (29308–38381)
Lung	33.2	8.4	26449	36185	35684 (34696–36667)
Lymphoma	66.9	39.0	27236	45791	44599 (42256–46935)
Melanoma of the skin	93.8	72.4	3818	9299	8939 (7950–10199)
Pancreas	17.8	2.5	29814	36112	35829 (33438–38216)
Prostate	95.0	75.3	10626	20021	19378 (18774–19973)
Renal	70.5	43.5	23920	36961	36138 (33223–39066)
Urinary bladder	85.3	55.8	13466	24781	24051 (22731–25386)
All other tumor sites	58.1	29.2	18960	29224	28601 (27229–29284)
Women					
Brain and ONS	20.7	5.5	37641	43925	43659 (39468–47850)
Breast	93.8	74.2	11748	18297	17857 (17290–18439)
Cervix	71.4	43.2	23795	31395	30969 (28009–33939)
Colorectal	74.9	47.5	25903	35637	35037 (34059–36016)
Corpus uteri	87.8	65.7	16485	22840	22451 (21212–23709)
Esophagus	39.0	13.5	32929	44108	43528 (37137–49914)
Gastric	41.1	16.8	32056	42440	41899 (38578–45226)
Head and neck	71.4	40.0	22633	34247	33558 (30114–36996)
Leukemia	50.2	25.5	22864	38852	37860 (34603–41106)
Liver	29.7	7.4	25398	37463	36776 (30548–43014)
Lung	38.7	11.8	26764	37873	37288 (36266–38315)
Lymphoma	68.9	43.9	25805	42214	41148 (39070–43215)
Melanoma of the skin	94.8	76.0	3463	6814	6594 (5262–7975)
Ovary	55.6	18.8	36550	56925	55748 (53225–58276)
Pancreas	18.0	2.0	30357	36743	36465 (34534–38391)
Renal	70.4	46.2	23836	36717	35899 (32827–38972)
Urinary bladder	79.1	54.0	14313	23175	22621 (20574–24663)
All other tumor sites	58.9	32.4	19215	29192	28580 (27332–29829)

* Phase-specific net cost of care estimates applied to survival probabilities among elderly cancer patients diagnosed 1998–2004. All cost estimates are in 2004 dollars. Data sources were 13-registry Surveillance, Epidemiology, and End Results (SEER) data (survival), and SEER–Medicare data (mean net costs by phase of care). ONS = other nervous system.

and treatment on costs of care and survival (26). For example, as new screening tools are introduced, evaluating test performance characteristics, lead time, extent of stage shift, cost, and effects on survival will be important to understanding their effectiveness.

Consistent with earlier studies (5–7,27,28), we found that mean net costs of cancer care were highest in the initial and last year of life phases and lower in the continuing phase and that they followed a nonlinear U-shaped curve. We also found that, within phase of care, net costs of care varied by tumor site and stage at diagnosis, with costs generally higher for patients diagnosed with distant disease than for patients diagnosed with localized disease. For cancers that are rarely diagnosed at early stages and with relatively short survival duration (ie, esophageal, gastric, lung, and pancreatic cancers), differences in cost by stage at diagnosis were smaller. These relative relationships by tumor site are generally consistent with previous estimates of the costs of care across multiple tumor sites by phase of care (5,6,13) and with a recent study that estimated patient time costs (29). The relationship between our aggregate 5-year net cost estimates in all newly diagnosed cancer patients and previous aggregate net cost estimates in all prevalent cancer patients (3) was consistent with the relationship between 5-year net cost estimates for colorectal cancer patients and net cost estimates for prevalent colorectal cancer patients published elsewhere (23). Our estimates differ somewhat from previous estimates of lifetime costs of care in elderly cancer patients (5) because our estimates represent net costs (ie, the difference between costs for cancer patients and costs for similar noncancer control subjects) and are only for a 5-year period.

We also found variation in net costs for the last year of life phase of care by tumor site and stage at diagnosis, with generally higher costs for patients with more advanced disease at initial diagnosis than patients diagnosed with localized disease. This variation may reflect differences in cause of death in patients with different stage at diagnosis and different cancers (cancer-related vs non–cancer-related deaths) and shorter survival among patients originally diagnosed with more advanced disease for some tumor sites than others. Currently, there are several commonly accepted approaches for classifying care costs for short-term survivors when

Table 6. Aggregate 5-year costs of care for the cohort of elderly Medicare cancer patients diagnosed in 2004*

Tumor site	Women		Men		Total 5-year costs, million $
	No. of patients in United States	5-year costs, million $	No. of patients in United States	5-year costs, million $	
Brain and ONS	3223	141	3173	152	293
Female breast	77008	1375	0	0	1375
Cervix	2369	73	0	0	73
Colorectal	44838	1571	41788	1530	3101
Corpus uteri	15131	340	0	0	340
Esophagus	2392	104	5896	282	386
Gastric	5912	248	8512	376	624
Head and neck	5231	176	10338	317	492
Leukemia	7923	300	9712	395	695
Liver	2908	107	5042	171	278
Lung	54665	2038	61646	2200	4238
Lymphoma	16112	663	15408	687	1350
Melanoma of the skin	7981	53	14404	129	181
Ovary	9088	507	0	0	507
Pancreas	11758	429	9565	343	771
Prostate	0	0	118369	2294	2294
Renal	7750	278	11250	407	685
Urinary bladder	11304	256	31892	767	1023
All other tumor sites	38954	1113	45585	1304	2417
Total	324546	9771	392581	11353	21124

* All cost estimates discounted by 3% annually and reported in 2004 dollars. ONS = other nervous system. Data sources were 17-registry Surveillance, Epidemiology, and End Results (SEER) data (cancer incidence in 2004) and 13-registry SEER data (survival) and SEER–Medicare (net costs by phase of care).

evaluating costs over time—costs can be classified as the last year of life because the content of care is similar to that in the last year of life (15), reported separately for short-term survivors and long-term survivors (5), or split between the initial and last year of life phases (7). In this study, we classified short-term survivors in the last year of life phase of care because we applied costs to life tables by phase of care to estimate long-term costs of care. Comparisons of different methods of classifying costs for short-term survivors and control subjects will be an important area for additional research.

Similarly, comparisons of different incidence and prevalence approaches to estimating costs of cancer care will be important for future work, among patients with cancers who have high median survival and among patients with cancers who have low median survival. The phase of care approach to estimating costs as applied to 5-year survival data in this study most closely resembles an approach in which an incident cohort of newly diagnosed patients is followed for 5 years. This modeled phase of care approach has several advantages over an incident cohort approach in that it is a more efficient use of data, particularly for less common tumor sites, and may better reflect rapidly changing treatment patterns because more recently diagnosed patients are included in estimates. Prevalence approaches that identify all cancer survivors in a specified period (eg, 5 years) and then estimate costs of care can be compared for different data sources, such as SEER–Medicare and the Medical Expenditure Panel Survey. For tumor sites with very short survival (eg, pancreas), cost estimates using incidence approaches may be similar to those using prevalence approaches.

Hospitalizations were the single largest component of cost for most tumor sites across phases of care, although the intensity varied by tumor site. Further exploration of the content and costs of care across tumor sites will be important for future research, especially with the introduction of more effective but more expensive chemotherapy treatments (30). Our estimates were based on most recent years of newly diagnosed cancer patients and Medicare claims data and did not reflect more recent diffusion of these newer chemotherapy agents. Given the dynamic nature of the health-care delivery system and innovations in cancer treatments, it will also be important to develop consistent time trends in the cost of cancer care by category of service, such as surgery, other inpatient care, chemotherapy, radiation therapy, supportive care, and hospice care.

Our cost estimates were for the elderly cancer patient population and may understate costs for younger cancer patients, who tend to seek more aggressive surgical care (31–33) and more adjuvant treatment (34) than older cancer patients. Additionally, because younger noncancer patients tend to use health care less than older noncancer patients, costs might be lower in younger control subjects than in older control subjects. Lower costs in younger control subjects might also contribute to higher net costs in younger cancer patients. Evaluation of the costs of care for younger and older cancer patients treated in the same settings will be an important area for additional research. Although managed care organizations include patients of all ages, an individual health plan may have insufficient numbers of cancer patients to evaluate costs by tumor site. The Cancer Research Network, which pools information about medical care that cancer patients receive across many managed care organizations, may be an ideal setting for additional research on this issue within managed care populations (35).

To estimate aggregate costs of cancer care in all cancer patients, phase of care cost estimates such as the ones obtained in this study could be applied to national prevalence estimates by phase of care. Currently, however, national prevalence estimates

by phase of care are available only for colorectal cancer (2). Therefore, development of national estimates for other tumor sites will allow updated and more precise estimation of the national cancer-related costs of care. Such estimates could inform the development of programs and policies throughout the cancer control continuum, including prevention, screening, treatment, surveillance, and end-of-life care.

Despite the strengths of a large population-based sample and use of established methods to estimate the costs of cancer care, our study had several limitations. Although the population included in SEER is generally representative of the US population (36), SEER counties tend to be slightly more urban and to have a higher proportion of foreign-born residents than all counties in the United States. Geographic variation in cancer incidence may not be fully reflected in our estimates of costs of cancer care to Medicare, however. Our cost estimates did not include out-of-pocket expenses or co-payments and were based on the approximately 85% of Medicare enrollees in fee-for-service plans. The Office of the Actuary for the Centers for Medicare and Medicaid Services estimated that patient deductibles and coinsurance expenses averaged approximately 7% for Medicare Part A and approximately 20% for Medicare Part B over the time period of this study (Gerald Riley, personal communication, 2008). Stage at diagnosis (37) and survival (38) have been reported elsewhere to vary between Medicare managed care and fee-for-service settings. Exploration of potential selection biases and differences in the costs of cancer care by delivery setting will be an important area for additional research.

In summary, aggregate costs of care for the elderly in the United States are substantial and vary by tumor site, phase of care, stage at diagnosis, and duration of survival. These estimates represent a basis for projections of cancer costs that will be particularly important with the growth and aging of the US population.

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Notes

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