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Influence of NCI Cancer Center Attendance on Mortality in Lung, Breast, Colorectal, and Prostate Cancer Patients

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Abstract

Some evidence links cancer outcomes to place of service, but the influence of NCI (National Cancer Institute) cancer centers on outcomes has not been established. We compared mortality for NCI cancer center attendees versus nonattendees. This retrospective cohort study included individuals with incident cancers of the lung, breast, colon/rectum, or prostate from 1998 to 2002 (N = 211,084) from SEER (Surveillance, Epidemiology, and End Results)–Medicare linked data, with claims through 2003. We examined the relation of NCI cancer center attendance with 1- and 3-year all-cause and cancer-specific mortality using multilevel logistic regression models. NCI cancer center attendance was associated with a significant reduction in the odds of 1- and 3-year all-cause and cancer-specific mortality. The mortality risk reduction associated with NCI cancer center attendance was most apparent in late-stage cancers and was evident across all levels of comorbidities. Attendance at NCI cancer centers is associated with a significant survival benefit for the four major cancers among Medicare beneficiaries.

Keywords

cancer; mortality; Medicare; Cancer Centers; cancer outcomes

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Introduction

Evidence linking cancer outcomes to physician and hospital attributes suggests that greater specialization and higher surgical volume are beneficial to patients. Several studies have shown that care by oncologists or oncology subspecialists leads to improved treatment (Earle, Neumann, Gelber, Weinstein, & Weeks, 2002) and survival (Gillis & Hole, 1996; Grilli et al., 1998), although this may not be true for some late-stage cancers (Rose et al., 2000). Higher procedure volumes for both surgeons and hospitals have also been linked to lower surgical mortality in cancer patients (Bach et al., 2001; J. D. Birkmeyer et al., 1999; J. D. Birkmeyer et al., 2002; N. J. Birkmeyer, Goodney, Stukel, Hillner, & Birkmeyer, 2005; Finlayson & Birkmeyer, 2003; Finlayson, Goodney, & Birkmeyer, 2003; Schrag, Bach, Dahlman, & Warren, 2002; Schrag et al., 2000; Schrag et al., 2003).

The most specialized institutions for cancer care and research in the United States are NCI (National Cancer Institute)-designated cancer centers. The NCI's cancer centers program was established in 1971 to foster regional centers of excellence in cancer research and clinical practice. The qualifying institutions have a high concentration of specialists, high surgical volumes, and multidisciplinary teams of clinicians and scientists. Furthermore, NCI cancer centers are believed to be at the forefront of advancing and adopting new therapeutics as well as advancing protocols of established best practices. This specialization in cancer care is expected to improve patient outcomes (Laliberte, Fennell, & Papandonatos, 2005; National Cancer Institute, 2005).

To date, only one study has looked at the effect of NCI cancer centers on cancer outcomes. In this study, a comparison of surgical mortality rates for six cancers at NCI cancer centers versus volume-matched hospitals showed a postsurgical mortality reduction (at <30 days) in four of the six procedures but no differences at 5 years (N. J. Birkmeyer et al., 2005). The effect of NCI cancer center attendance on overall mortality has not been examined and is important to consider given the demonstrated variation in geographic access to and use of NCI cancer centers among cancer patients (Onega, Duell, Shi, Demidenko, & Goodman, 2009; Onega et al., 2008). We examined the influence of NCI cancer center attendance on 1- and 3-year mortality for the major cancers: breast, lung, colorectal, and prostate.

New Contribution

Our research contributes to the cancer control literature as well as to health care delivery and health policy literature. This work expands on previously demonstrated variation in outcomes for cancer patients in relation to the place of service. We augment the sparse literature with which we can understand the impact of specialized care on cancer outcomes by presenting the first examination of nonsurgical cancer outcomes at NCI cancer centers compared with other types of facilities. In our cohort of more than 200,000 Medicare beneficiaries with an incident diagnosis of lung, breast, colorectal, or prostate cancer, more than 40% did not receive cancer-directed surgery during their treatment phase. Thus, the influence of attending an NCI cancer center on the outcomes of a sizable proportion of cancer patients is unknown.

Although NCI cancer centers received almost $250 million in core support funding in 2004 (National Cancer Institute, 2009a), whether these resources have translated into better outcomes for cancer patients has not been tested empirically beyond the surgical setting. The implications of establishing whether resources allocated to NCI cancer centers directly benefit patients extend to regionalized planning of care. Regionalization of specialized cardiac facilities was shown to reduce facility redundancy and lessen the negative impact of low-volume providers on patient outcomes while decreasing geographic access for only a small proportion of the population (Grumbach, Anderson, Luft, Roos, & Brook, 1995). For

cancer care, NCI cancer centers serve as de facto regionalized facilities. What is not known is whether these differ significantly in quality from other specialized settings, such as academic medical centers. Exploring the premise that NCI cancer centers serve as centers of excellence is a vital component to informing these resource allocation and organizational aims as well as providing a basis for patient decision making in where to seek care. We provide the most in-depth study of mortality among cancer patients at NCI cancer centers and compare it with the mortality in other institutions.

Method

Conceptual Framework

Our examination of the influence of NCI cancer center attendance on mortality among cancer patients was based on Andersen's behavioral model of health services and access to care (Andersen, 1995). This model provides a framework to understand the use of health care in terms of the environment (health care system and external environment), population characteristics, health behaviors, and outcomes. Our research sought to characterize the relations of a particular health care system (NCI cancer centers) on the broad outcome measure—namely, mortality—while accounting for many of the factors integral to the Andersen model. Specifically, we included predisposing characteristics such as race/ethnicity, group level income, comorbidity burden, and stage at diagnosis. We included the following enabling factors: per capita oncologist supply and travel time to the nearest NCI cancer center in our analyses. We derived measures of health behaviors through our NCI cancer center attendance definition and a measure of the dominant provider type (generalist vs. specialist) used prior to diagnosis.

Study Population

The study population was derived from SEER (Surveillance, Epidemiology, and End Results)–Medicare data, selected for incident primary cases of breast, lung, colorectal, or prostate cancer from 1998 to 2002, which were linked to Medicare claims through 2003. Currently, the 14 SEER registries represent ~26% of the U.S. population (National Cancer Institute, 2009b). For the cancer types included—lung, breast, colorectal, and prostate—the majority occur in individuals more than 65 years of age (National Cancer Institute, 2002).

Data from the Hawaii registry were not obtained because we were unable to obtain patient zip code (a restricted variable) for this state. The following groups were excluded from our study: Washington State residents were excluded because of systematically missing data for the NCI cancer center in the Seattle/Puget Sound registry ($n = 15,661$). Further exclusion criteria were: unequal parts A and B Medicare enrollment ($n = 24,657$) because of limitations in service ascertainment, any enrollment in a Medicare risk-bearing HMO in the 12 months prior to diagnosis ($n = 113,854$), <66 years of age at diagnosis (121,411), indeterminate month of diagnosis ($n = 2,357$), initial entitlement resulting from end-stage renal disease ($n = 164$), cancer diagnosis prior to 1998 ($n = 23,789$), death within 1 month of diagnosis ($n = 20,247$), and absence of MedPAR or outpatient claims in the first 12 months following diagnosis ($n = 7,380$). Of the 229,143 cases remaining, 14,121 were multiple primary cancers; thus, our base cohort of individuals included 215,022 individuals. Patients with only one facility-based claim (MedPAR or outpatient) in the first year following diagnosis ($n = 3,974$) were further excluded for the main analysis because we aimed to capture care beyond surgery. From a total of 558,663 cancer cases, we excluded 329,520.

Data and Variables

We calculated travel time to nearest NCI cancer center and per-capita oncologist supply, as described previously (Onega et al., 2008). Briefly, the shortest travel time route was

calculated from each zip code tabulation area population centroid to the nearest NCI cancer center based on a national major and minor road network with associated speed limits (TeleAtlas, Lebanon, NH; Onega et al., 2008). Travel time was computed using a closest facility algorithm (J. D. Birkmeyer, Siewers, Marth, & Goodman, 2003) in ArcView GIS (3.3) Network Analyst (Environmental Systems Research Institute, Redlands, CA), which creates unique origin–destination pairs and then determines the one-way travel time in minutes between them. Per-capita oncologist supply was calculated by linking oncologist counts by ZIP code of practice location with population counts (U.S. Census, 2000) to determine the ratio. Oncologists were identified through the American Medical Association masterfile as physicians with a self-designated, postgraduate medical education oncology specialty as their major professional activity. ZIP codes were then aggregated to the hospital referral region (pHRR) level. Rural status was assigned by linking patient ZIP code to a 4-tier rural urban commuting area (RUCA version 2.0) classification (Washington State Department of Health, 2006). During our study period (1998-2003), 47 institutions held continuous designation as a comprehensive or clinical NCI cancer center. Of these, 15 were located within SEER areas corresponding to the most recent complete data and, thus, were the NCI cancer centers included in our analyses.

NCI cancer center attendance was defined as two or more claim days for inpatient or outpatient procedural care occurring at an NCI cancer center within 12 months of the index cancer diagnosis as recorded by SEER. A claim day was defined as one calendar date on which one or more of the above claims occurred; inpatient stays were considered as one claim, and outpatient claims occurring during an inpatient stay were not counted. The index cancer was defined as the first primary cancer of the breast, lung, colon/rectum, or lung within the study period. Claims were identified as occurring at an NCI cancer center through the SEER–Medicare Hospital file (Schrag et al., 2002). Individuals with an incident diagnosis of breast, lung, colorectal, or prostate cancer from 1998 to 2002 were identified in SEER, along with their Medicare claims from 1997 through 2003. We used date of death as recorded in the Medicare denominator file. To account for possible referral and/or health care encounter patterns that might influence mortality we measured dominant physician care type in the 6 months prior to diagnosis. This measure was derived by tabulating physician encounters as recorded in carrier claims according to physician type, generalist or specialist, and assigning primary care predominance to those with ≥50% generalist care. We also adjusted for comorbid conditions identified by International Classification of Diseases (ICD-9) codes for all hospital and physician encounters within 12 months preceding the date of diagnosis, then calculated a Charlson score, modified to exclude solid tumors (Charlson, Pompei, Ales, & MacKenzie, 1987; Iezzoni et al., 1992; Klabunde, Potosky, Legler, & Warren, 2000; Klabunde, Warren, & Legler, 2002). Receipt of cancer-directed surgery in the first year following diagnosis was determined using appropriate procedure codes from the ICD-9 and Current Procedural Terminology.

Racial/ethnic categories were broadly defined as Caucasian, African American, Asian, Hispanic, Native American, and Other. These categories were mutually exclusive and were derived from self-report during application for processing at the social security administration. Group-level variables included median household income and educational attainment for the ZIP code of residence. We found median income and median education by ZIP to be 99% correlated, so we only included median income in our analyses.

Analysis

We evaluated 1- and 3-year mortality to capture survival differences between the cancer types by modeling mortality as a logit function of NCI cancer center attendance. We examined all-cause, cancer-specific, and other-cause mortality. We created models for all four cancers combined and stratified by cancer type, stage at diagnosis, and Charlson

comorbidity index. We also applied the same logistic regression model to the cohort stratified by receipt of cancer-directed surgery in the first year after diagnosis and stage at diagnosis. Stage at diagnosis was stratified based on TNM staging classification 1 to 4 and based on "early" (Stages 1 and 2) and "late" (Stages 3 and 4). Logistic regression models of mortality were adjusted for age, sex, predominance of primary care prior to diagnosis, SEER registry at diagnosis, and per-capita oncologist supply of pHRR of residence.

Empirical evidence of what constitutes NCI cancer center attendance is absent from the literature. Thus, to validate that the NCI cancer center attendance definition was robust, we examined the sensitivity of our model of attendance by changing the threshold criteria. We compared model performance with our base definition of ≥2 claim days in the first 12 months from diagnosis to NCI cancer center attendance defined as (a) ≥1 claim day in the first 12 months from diagnosis, (b) only surgical claim(s), and (c) proportion of claim days within first year ≥50%. We also stratified by year of diagnosis to ascertain whether SEER expansion in 2000 (National Cancer Institute, 2009b) had any effect on mortality.

To assess whether our mortality models could distinguish between attendance at various settings, we evaluated the following comparison groups: (a) NCI cancer center attendees versus all others (base model); (b) NCI cancer center attendees versus those at other specialized hospitals (teaching, referral, or American College of Surgeons Oncology Group (ACSOG) accredited, as identified in the hospital file-linked claims); and (c) attendees at non–NCI cancer center specialized hospitals as above versus other hospitals.

In addition to measuring associations of NCI cancer center attendance with mortality, we also estimated effect sizes. We calculated the attributable fraction and population attributable fraction, using a modified formula to account for potential confounding (Rockhill, Newman, & Weinberg, 1998). All analyses were performed using Stata statistical software v. 9.2 (Stata Corporation, College Station, TX). This study was approved by the Committee for Protection of Human Subjects at Dartmouth Medical School.

Results

Our study population consisted of 211,084 Medicare beneficiaries who had an incident primary cancer of the breast, lung, colon/rectum, or prostate from 1998 to 2002. Of these, 15,377 (7.3%) had two or more claims at an NCI cancer center within a year of diagnosis; 49,993 (23.7%) had their first (or only) cancer during the study period in the breast, 49,129 (23.3%) in the lung, 49,533 (23.5%) in the colon/ rectum, and 62,393 (29.6%) in the prostate.

Baseline characteristics between NCI cancer center attendees versus nonattendees mainly differed with respect to the following: receipt of surgery (59.6% vs. 57.4%), predominance of primary care prior to diagnosis (42.4% vs. 47.9%), Caucasians (82.5% vs. 87.2%), African Americans (13.0% vs. 8.2%), age at diagnosis (median of 73 years vs. 75), travel time to nearest NCI cancer center (median 24 minutes vs. 51 minutes), and per-capita oncologists (median 3.5/100,000 in pHRR vs. 2.6/100,000; Table 1). Cancer-specific mortality accounted for the majority of mortality events at both 1 and 3 years, except for early-stage cancers (Table 2). All the mortality measures were highest among African Americans, when calculating within-group proportions (Table 2).

We first created adjusted overall models of all-cause, cancer-specific, and other-cause mortality at 1 and 3 years to assess the effect of NCI cancer center attendance on these outcomes. NCI cancer center attendance was significantly associated with decreased odds of mortality at 1 and 3 years, even after adjusting for all independently associated covariates (Table 3). The likelihood of mortality 1 year from diagnosis among NCI cancer center

attendees was about 25% lower compared with nonattendees (all-cause mortality: odds ratio [OR] = 0.75, 95% confidence interval [CI] = 0.71-0.79; cancer-specific mortality: OR = 0.75, 95% CI = 0.70-0.79; other-cause mortality: OR = 0.74, 95% CI = 0.67-0.82). Similarly, the likelihood of having died within 3 years of diagnosis was significantly lower for NCI cancer center attendees, although the effect is not as strong as at 1 year (all-cause mortality: OR = 0.88, 95% CI = 0.84-0.92; cancer-specific mortality: OR = 0.91, 95% CI = 0.86-0.96; other-cause mortality: OR = 0.80; 95% CI = 0.74-0.87). We consistently found no effect of diagnosis year in univariate, stratified, or full models of mortality as a function of NCI cancer center attendance (data not shown).

Cancer Type Stratification

To examine the influence of NCI cancer center attendance on mortality within specific subgroups of patients, we developed logistic models of 1- and 3-year mortality stratified by cancer type, stage at diagnosis, and comorbidity status (Table 4). In adjusted models, NCI cancer center attendance was associated with significantly reduced odds of 1-year stage-adjusted mortality for breast cancer (OR = 0.72; 95% CI = 0.60-0.85), lung cancer (OR = 0.71; 95% CI = 0.66-0.77), colorectal cancer (OR = 0.80; 95% CI = 0.71-0.90), and prostate cancer (OR = 0.78; 95% CI = 0.67-0.90). The OR of mortality at 3 years also was significantly lower among NCI cancer center attendees with lung cancer (OR = 0.85; 95% CI = 0.78-0.91) and prostate cancer (OR = 0.83 95% CI = 0.75-0.91). Cancer-specific mortality associations were similar to all-cause mortality for all four cancers at both 1 and 3 years (Table 4). The association of NCI cancer center attendance with other-cause mortality followed similar patterns as for cancer-specific mortality, except for at 1 year among breast cancer patients (other-cause mortality: OR = 0.88, 95% CI = 0.68-1.12; cancer-specific mortality: OR = 0.62, 95% CI = 0.49-0.77) and at 3 years for colorectal cancer patients (other-cause mortality: OR = 0.84, 95% CI = 0.72-0.98; cancer-specific mortality: OR = 0.96, 95% CI = .0.86-1.07).

Stage Stratification

We examined the influence of NCI cancer center attendance on mortality for early- and late-stage cancers. The likelihood of 1-year mortality was significantly lower with NCI cancer center attendance for both early and late stage cancers, although the effect was more pronounced among patients diagnosed at a late stage (cancer-specific mortality—early stage: OR = 0.82, 95% CI = 0.69-0.99; cancer-specific mortality—late stage: OR = 0.70; 95% CI = 0.65-0.75; Table 4). Cancer-specific mortality likelihood reduction at 3 years was limited to late-stage patients, with a 15% decline evident (OR = 0.85; 95% CI = 0.79-0.91).

Comorbidity Burden Stratification

To better account for potential differences in case-mix severity between NCI cancer center attendees and nonattendees, we modeled the effect of NCI cancer center attendance on mortality among strata of increasing comorbidity burden. NCI cancer center attendance was associated with a 26% decrease in the odds of cancer-specific mortality at 1 year from diagnosis for all comorbidity groups, and between an 8% and 13% decrease at 3 years (0 comorbidities: OR = 0.92, 95% CI = 0.85-0.98; 1-2 comorbidities: OR = 0.91, 95% CI = 0.82-1.00; 3 or more comorbidities: OR = 0.87, 95% CI = 0.76-1.00; Table 4).

Cancer Surgery and Mortality

We also examined the influence that receipt of cancer-directed surgery had on models of NCI cancer center attendance and mortality. In models stratified by cancer-directed surgery in the first year from diagnosis, the OR of NCI cancer center attendance for 1-year cancer-specific mortality was somewhat lower among patients with no cancer-directed surgery,

although both showed a similar reduction in the odds of mortality among NCI cancer center attendees (received surgery: 1-year OR = 0.79, 95% CI = 0.72-0.87; without surgery: OR = 0.70, 95% CI = 0.64-0.75; Table 4). The odds of 3-year cancer-specific mortality was 17% lower among patients without surgery who attended NCI cancer centers as compared with patients without surgery who went elsewhere (OR = 0.83; 95% CI = 0.77-0.90). Among cancer patients with surgery, there was no significant difference in cancer-specific 3-year mortality likelihood based on NCI cancer center attendance.

Sensitivity Analysis

Sensitivity analysis of NCI cancer center attendance definition in models of 1- and 3-year mortality demonstrated robustness of the definition of NCI cancer center attendance across four definitions of the same. We altered our base definition of two or more claims to the following, all within a year of diagnosis and occurring at an NCI cancer center: 1, one claim; 2, surgical claim(s) only; and 3, ≥50% of all claim days. The odds ratios ranged from 0.47 (95% CI = 0.41-0.52) to 0.71 (95% CI = 0.67-0.7) for 1-year mortality and from 0.58 (95% CI = 0.54-0.64) to 0.86 (95% CI = 0.83-0.90) for 3-year mortality, with a trend of greater effect seen with greater stringency of definition.

We compared the influence of three different types of attendance on 1- and 3-year mortality: (a) NCI cancer center versus non-NCI specialty hospitals (teaching, referral, ACSOG); (b) non-NCI specialty hospitals versus all other hospitals; and (c) NCI cancer centers versus all other hospitals. The odds of cancer-specific 1-year mortality with attendance at an NCI cancer center versus other hospital (excluding non-NCI specialty hospitals) was the lowest (OR = 0.74; 95% CI = 0.69-0.79; Table 5). Attendance at an NCI cancer center versus a non-NCI specialty hospital was associated with a 25% decrease in the odds of cancer-specific 1-year mortality (OR = 0.75; 95% CI = 0.71-0.80). Mortality at facilities other than NCI cancer centers was largely similar, with the exception of a 6% lower likelihood of cancer-specific mortality at 1 year at non-NCI specialty hospitals compared with other hospitals. The impact of hospital type attended was greatest for cancer-specific 1-year mortality. Patterns for all-cause mortality were similar to those for cancer-specific mortality.

Effect Size Estimates

Determination of the fraction of 1-year mortality reduction attributable to attending an NCI cancer center among individuals who did attend was 35.1% and was 13.6% for 3-year mortality. For the population as a whole, the fraction of mortality attributable to not attending an NCI cancer center was 2.0% at 1 year and 1.0% at 3 years. Given the proportion of patients attending an NCI cancer center in our cohort of over 200,000 individuals, this would translate to >4,000 fewer deaths at 1 year and >2,000 fewer deaths at 3 years if all patients attended an NCI cancer center.

Discussion

We examined the influence of NCI cancer center attendance on the likelihood of mortality at 1 and 3 years in Medicare beneficiaries with breast, lung, colorectal, or prostate cancer. Among patients who attended an NCI cancer center, we found a significant reduction in cancer-specific 1- and 3-year mortality relative to patients who did not attend NCI cancer centers. A decreased likelihood of cancer-specific mortality at 1 year from diagnosis was evident for all four cancers examined in adjusted models. Furthermore, an overall decrease in cancer-specific 1- and 3-year mortality was associated with NCI cancer center attendance in multivariate models stratified by comorbidity burden. The influence of NCI cancer center attendance was greatest for later stage cancers. The significantly lower likelihood of mortality among NCI cancer center attendees was apparent for both surgical and nonsurgical

patients. Models were not sensitive to NCI cancer center attendance definition. The influence of hospital attendance on mortality was greatest when comparing NCI cancer center attendance with hospitals other than teaching, referral, or ACSOG-accredited hospitals.

Although the association of hospital type and mortality in cancer care has not been examined previously in detail, we may expect specialized institutions, such as NCI cancer centers, to demonstrate better survival for cancer patients for several reasons. First, previous studies found improved survival for cancer patients in high-volume hospitals (J. D. Birkmeyer et al., 1999; J. D. Birkmeyer et al., 2002; Finlayson et al., 2003; Hillner, Smith, & Desch, 2000; Hodgson et al., 2003; Schrag et al., 2003). Second, evidence supports improved cancer outcomes in patients treated by specialists (Earle et al., 2002; Gillis & Hole, 1996; Grilli et al., 1998). To date, there has been little research on the effect of hospital attributes other than volume on mortality in cancer patients. Evidence not limited to cancer patients demonstrates improved survival for Medicare beneficiaries at teaching, not-for-profit hospitals (Yuan, Cooper, Einstadter, Cebul, & Rimm, 2000). One study focused specifically on surgical outcomes at NCI cancer centers reported improved short-term surgical mortality (<30 days after the index surgery), but no long-term survival benefit at 5 years (N. J. Birkmeyer et al., 2005). Our result of lower mortality at 1 and 3 years also demonstrates a benefit with NCI cancer center attendance, albeit with an attenuated effect at 3 years. This survival benefit may be related to processes of care, such as receipt of surgery, guideline-based treatment, and multidisciplinary care teams. Among patients who died within 1 year of diagnosis, we did not assess date of death in relation to date of surgery, so the effect may be similar to that reported by N. J. Birkmeyer et al. (2005).

By measuring cancer-specific death in addition to all-cause and noncancer deaths, we were able to more confidently attribute the observed mortality odds reductions to NCI cancer center attendance per se rather than to case-mix differences in those who attend NCI cancer centers versus other institutions. The significantly decreased likelihood of mortality from noncancer causes for many of our mortality models suggests that NCI cancer centers may have overall improved processes of care, beyond those related just to cancer, or that we may still have unobserved baseline differences in our comparison populations, even after adjusting for important covariates. The models of mortality stratified by comorbidities and adjusted for cancer, stage, receipt of surgery, and other factors showed lower cancer-specific and other-cause mortality ORs, lending support to the interpretation of higher overall quality of care at NCI cancer centers. However, because we cannot measure comorbidity severity and other clinical factors, the potential for selection bias exists.

We measured the influence of NCI cancer centers on mortality likelihood for both surgical and nonsurgical care. Our approach closely links the effect of NCI cancer centers to patient outcomes by requiring more than one episode of care and by considering surgical and nonsurgical care at an NCI cancer center. Defining NCI cancer center attendance beyond surgical care may account for our ability to demonstrate a significant effect of NCI cancer center attendance on mortality. Reduction in the odds of nonsurgical mortality at NCI cancer centers was suggested in our study for breast, lung, colorectal, and prostate cancers, even when accounting for stage and comorbidities. This finding adds to the evidence that more specialized care improves cancer outcomes. Variation in mortality as a function of hospital type attended also implies that diffusion of best practices is incomplete.

The effect size on mortality of attending an NCI cancer center is estimated based on the prevalence of attendance, which was low (7.3%). Nevertheless, in our cohort of more than 200,000 patients a sizable number of deaths are estimated to be attributed to *not* attending an NCI cancer center: >4,000 at 1 year and >2,000 at 3 years. This estimate, if extended to the

entire population of cancer patients in the United States, could have major implications on cancer outcomes and lends support to the need to identify the components of care related to the observed mortality benefit.

This study had several limitations. First, we did not ascertain complete provider use longitudinally, such as for office-based physician visits. Second, as in any research on mortality in cancer, lead time bias may distort measures of survival/mortality. Our study attempted to minimize this possibility by controlling for stage at diagnosis. Although such a bias is possible, our results for lung cancer are unlikely to be influenced by lead-time bias because lung cancer, currently, is not screened for routinely, and clinical interventions typically yield only a modest benefit. Third, of the 15 NCI cancer centers located within the SEER regions, none is located in the Southeastern United States; thus, a potential for geographic bias exists.

In summary, we demonstrated a mortality benefit based on NCI cancer center attendance. This finding has potential implications for patients, institutions, and policy makers. Patients increasingly seek performance ratings to guide their decisions in health care. NCI cancer centers appear to be benchmarks of cancer care for survival. Further investigations of the aspects of care at cancer centers that afford this benefit would assist other institutions in improving their care. The most realistic strategy for improving care would be to disseminate models of care to the large number of existing cancer treatment facilities, rather than dramatically increasing the number of NCI cancer centers.

Mortality rates are one, albeit, important outcome of cancer care. Little is currently known about patients' views of care across different settings. Future research in this area will also be of great value in improving the overall care of patients with cancer.

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References

Andersen RM. Revisiting the behavioral model and access to medical care: Does it matter? Journal of Health and Social Behavior. 1995; 36:1–10. [PubMed: 7738325]

Bach PB, Cramer LD, Schrag D, Downey RJ, Gelfand SE, Begg CB. The influence of hospital volume on survival after resection for lung cancer. New England Journal of Medicine. 2001; 345:181–188. [PubMed: 11463014]

Birkmeyer JD, Finlayson SR, Tosteson AN, Sharp SM, Warshaw AL, Fisher ES. Effect of hospital volume on in-hospital mortality with pancreaticoduodenectomy. Surgery. 1999; 125:250–256. [PubMed: 10076608]

Birkmeyer JD, Siewers AE, Finlayson EV, Stukel TA, Lucas FL, Batista I, et al. Hospital volume and surgical mortality in the United States. New England Journal of Medicine. 2002; 346:1128–1137. [PubMed: 11948273]

Birkmeyer JD, Siewers AE, Marth NJ, Goodman DC. Regionalization of high-risk surgery and implications for patient travel times. Journal of the American Medical Association. 2003; 290:2703–2708. [PubMed: 14645312]

Birkmeyer NJ, Goodney PP, Stukel TA, Hillner BE, Birkmeyer JD. Do cancer centers designated by the National Cancer Institute have better surgical outcomes? Cancer. 2005; 103:435–441. [PubMed: 15622523]

Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. Journal of Chronic Diseases. 1987; 40:373–383. [PubMed: 3558716]

Earle CC, Neumann PJ, Gelber RD, Weinstein MC, Weeks JC. Impact of referral patterns on the use of chemotherapy for lung cancer. Journal of Clinical Oncology. 2002; 20:1786–1792. [PubMed: 11919235]

Finlayson EV, Birkmeyer JD. Effects of hospital volume on life expectancy after selected cancer operations in older adults: A decision analysis. Journal of the American College of Surgeons. 2003; 196:410–417. [PubMed: 12648693]

Finlayson EV, Goodney PP, Birkmeyer JD. Hospital volume and operative mortality in cancer surgery: A national study. Archives of Surgery. 2003; 138:721–725. discussion 726. [PubMed: 12860752]

Gillis CR, Hole DJ. Survival outcome of care by specialist surgeons in breast cancer: A study of 3,786 patients in the west of Scotland. BMJ (Clinical Research ed.). 1996; 312:145–148.

Grilli R, Minozzi S, Tinazzi A, Labianca R, Sheldon TA, Liberati A. Do specialists do it better? The impact of specialization on the processes and outcomes of care for cancer patients. Annals of Oncology. 1998; 9:365–374.

Grumbach K, Anderson GM, Luft HS, Roos LL, Brook R. Regionalization of cardiac surgery in the United States and Canada. Geographic access, choice, and outcomes. JAMA: The Journal of the American Medical Association. 1995; 274:1282–1288. [PubMed: 7563533]

Hillner BE, Smith TJ, Desch CE. Hospital and physician volume or specialization and outcomes in cancer treatment: Importance in quality of cancer care. Journal of Clinical Oncology. 2000; 18:2327–2340. [PubMed: 10829054]

Hodgson DC, Zhang W, Zaslavsky AM, Fuchs CS, Wright WE, Ayanian JZ. Relation of hospital volume to colostomy rates and survival for patients with rectal cancer. Journal of the National Cancer Institute. 2003; 95:708–716. [PubMed: 12759388]

Iezzoni LI, Foley SM, Daley J, Hughes J, Fisher ES, Heeren T. Comorbidities, complications, and coding bias. Does the number of diagnosis codes matter in predicting in-hospital mortality?. JAMA: The Journal of the American Medical Association. 1992; 267:2197–2203.

Klabunde CN, Potosky AL, Legler JM, Warren JL. Development of a comorbidity index using physician claims data. Journal of Clinical Epidemiology. 2000; 53:1258–1267. [PubMed: 11146273]

Klabunde CN, Warren JL, Legler JM. Assessing comorbidity using claims data: An overview. Medical Care. 2002; 40(8 Suppl.):IV–26. 35.

Laliberte L, Fennell ML, Papandonatos G. The relationship of membership in research networks to compliance with treatment guidelines for early-stage breast cancer. Medical Care. 2005; 43:471–479. [PubMed: 15838412]

National Cancer Institute. [Retrieved April 9, 2009] Age distribution (%) of incidence cases by site, 1998-2002. SEER Cancer Statistics Review 1975-2002. 2002. from http://seer.cancer.gov/csr/1975_2002/results_merged/topic_age_dist.pdf

National Cancer Institute. A conversation with Dr. Linda Weiss. NCI Cancer Bulletin. 2005; 2(11) from http://www.nci.nih.gov/ncicancerbulletin/NCI_Cancer_Bulletin_031505/page6.

National Cancer Institute. [Retrieved April 9, 2009] NCI mission statement. 2009a. from http://www.cancer.gov/aboutnci/overview/mission

National Cancer Institute. [Retrieved April 9, 2009] Surveillance epidemiology and end results. 2009b. from http://seer.cancer.gov/about/

Onega T, Duell EJ, Shi X, Demidenko E, Goodman D. Determinants of NCI cancer center attendance in Medicare patients with lung, breast, colorectal, or prostate cancer. Journal of General Internal Medicine. 2009; 24:205–210. [PubMed: 19067086]

Onega T, Duell EJ, Shi X, Wang D, Demidenko E, Goodman D. Geographic access to cancer care in the U.S. Cancer. 2008; 112:909–918. [PubMed: 18189295]

Rockhill B, Newman B, Weinberg C. Use and misuse of population attributable fractions. American Journal of Public Health. 1998; 88:15–19. [PubMed: 9584027]

Rose JH, O'Toole EE, Dawson NV, Thomas C, Connors AF Jr. Wenger N, et al. Generalists and oncologists show similar care practices and outcomes for hospitalized late-stage cancer patients. SUPPORT Investigators. Study to Understand Prognoses and Preferences for Outcomes and Risks for Treatment. Medical Care. 2000; 38:1103–1118.

Schrag D, Bach PB, Dahlman C, Warren JL. Identifying and measuring hospital characteristics using the SEER–Medicare data and other claims-based sources. Medical Care. 2002; 40(8 Suppl.):IV–96. 103.

Schrag D, Cramer LD, Bach PB, Cohen AM, Warren JL, Begg CB. Influence of hospital procedure volume on outcomes following surgery for colon cancer. JAMA: The Journal of the American Medical Association. 2000; 284:3028–3035. [PubMed: 11122590]

Schrag D, Panageas KS, Riedel E, Hsieh L, Bach PB, Guillem JG, et al. Surgeon volume compared to hospital volume as a predictor of outcome following primary colon cancer resection. Journal of Surgical Oncology. 2003; 83:68–78. discussion 78-79. [PubMed: 12772198]

U.S. Census Bureau. [Retrieved April 20, 2009] Total population and population by sex and age for 5-digit ZIP code tabulation areas in the United States. 2000. from http://factfinder.census.gov/servlet/DCGeoSelectServlet?ds_name=DEC_2000_SF1_U&_ts=259577013671

Washington State Department of Health. A suggested four-tiered consolidation of the RUCA system at the sub-county level. 2006. Retrieved April 9, 2009Retrieved April 9, 2009from http://www.doh.wa.gov/Data/Guidelines/RuralUrban.htm#suggested

Yuan Z, Cooper GS, Einstadter D, Cebul RD, Rimm AA. The association between hospital type and mortality and length of stay: A study of 16.9 million hospitalized Medicare beneficiaries. Medical Care. 2000; 38:231–245. [PubMed: 10659696]

Table 1

Characteristics of Medicare Beneficiaries Attending an NCI Cancer Center, and Others, With an Incident Diagnosis of Lung, Breast, Colorectal, or Prostate Cancer From 1998 to 2002 (N = 211,084) as Recorded in SEER

	NCI Cancer Center Attendance[a]	
	Yes, *n* (%)	**No, *n* (%)**
Total	15,377 (7.3)	195,671 (92.7)
Mortality		
None	11,462 (74.5)	139,405 (71.2)
1 Year from diagnosis		
All-cause	2,347 (15.3)	38,153 (19.5)
Cancer-specific	1,906 (12.4)	29,806 (15.2)
Other-cause	441 (2.9)	8,347 (4.3)
3 years from diagnosis		
All-cause	3,915 (25.5)	56,266 (28.8)
Cancer-specific	3,051 (19.8)	41,189 (21.1)
Other-cause	864 (5.7)	15,077 (7.7)
Cancer type		
Breast	3,554 (23.1)	46,439 (23.7)
Lung	3,749 (24.4)	45,380 (23.2)
Colorectal	2,864 (18.6)	46,669 (23.8)
Prostate	5,210 (33.9)	57,183 (29.2)
Cancer-directed surgery[b]	9,161 (59.6)	112,284 (57.4)
Female	6,791 (44.2)	93,370 (47.7)
Race/ethnicity		
Caucasian	12,690 (82.5)	170,607 (87.2)
African American	1,993 (13.0)	16,015 (8.2)
Asian	303 (2.0)	3,558 (1.8)
Hispanic	167 (1.1)	2,959 (1.5)
Native American	111 (<0.1)	320 (0.2)
Other	213 (1.4)	2,212 (1.1)
Predominance of primary care[c]	6,514 (42.4)	93,762 (47.9)
Rurality		
Urban core	12,080 (78.6)	138,721 (70.9)
Suburban areas	883 (5.7)	15,878 (8.1)
Large town areas	889 (5.8)	16,032 (8.2)
Small town and rural areas	1,525 (9.9)	25,040 (12.8)
Charlson comorbidity index		
0	9,966 (64.8)	118,077 (60.3)
1-2	3,736 (24.3)	50,340 (25.7)
3-4	1,263 (8.2)	19,499 (10.0)
5+	412 (2.7)	7,755 (4.0)

	NCI Cancer Center Attendance[a]	
	Yes, *n* (%)	**No, *n* (%)**
Stage		
1	3,383 (22.0)	46,731 (23.9)
2	2,023 (13.2)	30,864 (15.8)
3	2,180 (14.2)	26,713 (13.6)
4	2,350 (15.3)	26,260 (13.4)
Unknown	5,441 (35.4)	65,103 (33.3)
Median (Interquartile Range)		
Age at diagnosis	73 (69-77)	75 (70-80)
Travel time to nearest NCI cancer center (minutes)	24 (13-52)	51 (23-138)
Median income of ZIP ($1,000)	46.5 (35.3-61.4)	45.3 (34.7-59.3)
Physician supply		
Primary care per 1,000	1.3 (1.0-1.9)	1.2 (0.9-1.6)
Oncologists per 100,000	3.5 (2.4-4.0)	2.6 (2.0-3.8)

Note: NCI = National Cancer Institute; SEER = Surveillance, Epidemiology, and End Results.

[a]NCI cancer center attendance was defined as having two or more claim days in the first 12 months following diagnosis.

[b]Cancer-directed surgery was defined as surgical resection of the lung, bronchus, colon, rectum, breast, or prostate as identified in MedPAR and outpatient Medicare claims through International Classification of Diseases-9 and Current Procedural Terminology codes.

[c]Predominance of primary care was defined as having primary care visits ≥specialist visits in the 6 months prior to diagnosis.

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Table 2

Characteristics of Medicare Beneficiaries With Breast, Lung, Colorectal, or Prostate Cancer (1998-2003) With Mortality at 1- and 3-Years

		Mortality *n* (%)					
		1-Year Mortality			3-Year Mortality		
	Total *n*	All-Cause	Cancer-Specific	Other-Cause	All-Cause	Cancer-Specific	Other-Cause
Race/ethnicity							
Caucasian	183,297	34,461 (18.8)	27,008 (14.7)	7,453 (4.1)	51,080 (27.9)	37,523 (20.5)	13,557 (7.4)
African American	18,008	4,143 (23.0)	3,164(17.6)	979 (5.4)	6,263 (34.8)	4,546 (25.2)	1,717 (9.5)
Asian	3,861	722 (18.7)	582 (15.1)	140 (3.6)	1,084 (28.1)	841 (21.8)	243 (6.3)
Hispanic	3,126	546 (17.5)	438 (14.0)	108 (3.4)	845 (27.0)	629 (20.1)	216 (6.6)
Native American	331	71 (21.4)	59 (17.8)	12 (3.6)	107 (32.2)	85 (25.7)	22 (6.6)
Other	2,425	557 (23.0)	461 (19.0)	96 (4.0)	802 (33.1)	616 (25.4)	186 (7.7)
Cancer							
Breast	49,993	3,269 (6.5)	1,954 (3.9)	1,315 (2.6)	6,684(13.4)	3,612 (7.2)	3,072 (6.1)
Lung	49,129	24,048 (48.9)	21,183 (43.1)	2,865 (5.8)	30,678 (62.4)	26,672 (54.3)	4,006 (8.1)
Colorectal	49,533	9,372 (18.9)	6,445 (13.0)	2,927 (5.9)	14,675 (29.6)	9,799 (19.8)	4,876 (9.8)
Prostate	62,393	3,811 (6.1)	2,130 (3.4)	1,681 (2.7)	8,144(13.0)	4,157 (6.7)	3,987 (6.4)
Stage							
1 or 2	83,001	5,886 (7.1)	2,967 (3.6)	2,919 (3.6)	12,134(14.9)	6,118 (7.5)	6,016 (7.4)
3 or 4	57,503	25,140(43.8)	22,204 (38.6)	2,936 (5.1)	32,578 (56.7)	28,387 (49.4)	4,191 (7.3)
Unknown	70,544	9,474(13.4)	6,541 (9.3)	2,933 (4.2)	15,469 (21.9)	9,735 (13.8)	5,734 (8.1)
Charlson comorbidity index							
0	128,043	18,395 (14.4)	15,120 (11.8)	3,275 (2.6)	28,354 (22.1)	21,837 (17.0)	6,517 (5.1)
1-2	54,076	12,240 (22.6)	9,614(17.8)	2,626 (4.9)	18,058 (33.4)	13,277 (24.5)	4,781 (8.8)
3-4	20,762	6,589 (31.7)	4,882 (23.5)	1,707 (8.2)	9,266 (44.6)	6,424 (30.9)	2,842 (13.7)
5+	8,167	3,276(40.1)	2,096 (25.7)	1,180 (14.5)	4,503 (55.1)	2,702 (33.1)	1,801 (22.0)

Table 3

Predictive Models of 1- and 3-Year Mortality Among Medicare Beneficiaries With Breast, Lung, Colorectal, or Prostate Cancer From 1998 to 2002 (N= 211,084)

	Odds Ratio[a] (95% CI) for Mortality Measure					
	1-Year Mortality			3-Year Mortality		
Final Model Variables	**All-Cause**	**Cancer-Specific**	**Other-Cause**	**All-Cause**	**Cancer-Specific**	**Other-Cause**
NCI cancer center attendance[b]	0.75 (0.71-0.79)	0.75 (0.70-0.79)	0.74 (0.67-0.82)	0.88 (0.84-0.92)	0.91 (0.86-0.96)	0.80 (0.74-0.87)
Stage at diagnosis						
1	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
2	1.47 (1.39-1.55)	1.61 (1.49-1.74)	1.14 (1.05-1.23)	1.52 (1.45-1.58)	1.76 (1.67-1.86)	1.15 (1.08-1.21)
3	3.73 (3.56-3.91)	5.53 (5.21-5.87)	1.67 (1.54-1.80)	3.52 (3.38-3.66)	5.22 (4.98-5.48)	1.56 (1.47-1.66)
4	10.87 (10.35-11.41)	17.60 (16.57-18.70)	2.44 (2.25-2.66)	9.49 (9.09-9.89)	15.80 (15.03-16.61)	2.04 (1.90-2.19)
Unknown	2.29 (2.18-2.41)	3.04 (2.85-3.23)	1.46 (1.36-1.58)	2.10 (2.01-2.18)	2.63 (2.50-2.77)	1.41 (1.33-1.50)
Predominance of primary care[c]	1.27 (1.24-1.31)	1.26 (1.22-1.30)	1.28 (1.23-1.34)	1.24 (1.21-1.27)	1.22 (1.19-1.26)	1.25 (1.21-1.30)
Race/ethnicity						
Caucasian	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
African American	1.16 (1.10-1.22)	1.13 (1.07-1.19)	1.24 (1.14-1.34)	1.22 (1.17-1.28)	1.23 (1.17-1.30)	1.22 (1.14-1.30)
Charlson comorbidity index						
0	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1-2	1.49 (1.44-1.53)	1.37 (1.32-1.42)	1.85 (1.68-2.00)	1.55 (1.51-1.59)	1.41 (1.36-1.45)	1.86 (1.78-1.93)
3-4	2.12 (2.04-2.21)	1.78 (1.70-1.87)	3.07 (2.88-3.27)	2.23 (2.15-2.31)	1.81 (1.73-1.89)	3.04 (2.89-3.20)
5+	3.26 (3.08-3.45)	2.29 (2.14-2.46)	5.65 (5.24-6.10)	3.57 (3.38-3.76)	2.42 (2.26-2.58)	5.56 (5.21-5.94)

Note: NCI = National Cancer Institute; CI = confidence interval; SEER = Surveillance, Epidemiology, and End Results.

[a]Odds ratios were adjusted for age at diagnosis, sex, rurality, cancer, SEER registry of residence at diagnosis, per capita oncologist supply for hospital referral region, and median income for ZIP code of residence.

[b]Attendance is defined as two or more claim days in the first 12 months after diagnosis.

[c]Predominant primary care was defined as having primary care visits ≥specialist visits in the 6 months prior to diagnosis.

Table 4

Predictive Models of 1- and 3-Year Mortality as a Function of NCI Cancer Center Attendance for Models Stratified by Cancer Type, Stage at Diagnosis, Charlson Comorbidity Index, and Receipt of Cancer-Directed Surgery

	Odds Ratio[a] (95% CI) for Mortality Measure Among NCI Cancer Center Attendees vs. Nonattendees					
	1-Year Mortality			3-Year Mortality		
Stratification Factor	**All-Cause**	**Cancer-Specific**	**Other-Cause**	**All-Cause**	**Cancer-Specific**	**Other-Cause**
Cancer						
Breast	0.72 (0.60-0.85)	0.62 (0.49-0.77)	0.88 (0.68-1.12)	0.93 (0.82-1.04)	0.89 (0.77-1.04)	0.95 (0.81-1.11)
Lung	0.71 (0.66-0.77)	0.73 (0.67-0.79)	0.64 (0.54-0.77)	0.85 (0.78-0.91)	0.87 (0.80-0.94)	0.74 (0.64-0.85)
Colorectal	0.80 (0.71-0.90)	0.78 (0.68-0.89)	0.83 (0.68-1.00)	0.93 (0.84-1.02)	0.96 (0.86-1.07)	0.84 (0.72-0.98)
Prostate	0.78 (0.67-0.90)	0.80 (0.66-0.95)	0.73 (0.58-0.92)	0.83 (0.75-0.91)	0.88 (0.77-1.00)	0.76 (0.65-0.88)
Stage at diagnosis						
1 or 2	0.83 (0.73-0.95)	0.82 (0.69-0.99)	0.83 (0.69-1.00)	0.92 (0.84-1.01)	0.98 (0.87-1.10)	0.85 (0.75-0.96)
3 or 4	0.69 0.64-0.74)	0.70 (0.65-0.75)	0.63 (0.54-0.75)	0.84 (0.78-0.90)	0.85 (0.79-0.91)	0.77 (0.67-0.89)
Unknown	0.81 0.72-0.90)	0.81 (0.72-0.92)	0.78 (0.65-0.93)	0.87 (0.80-0.95)	0.94 (0.85-1.04)	0.77 (0.68-0.87)
Charlson comorbidity index						
0	0.76 0.71-0.83)	0.75 (0.69-0.81)	0.82 (0.70-0.95)	0.89 (0.84-0.95)	0.92 (0.85-0.98)	0.85 (0.76-0.95)
1-2	0.75 0.67-0.83)	0.74 (0.66-0.84)	0.74 (0.61-0.89)	0.87 (0.80-0.95)	0.91 (0.82-1.00)	0.78 (0.68-0.90)
3 Or more	0.71 0.63-0.81)	0.74 (0.64-0.87)	0.63 (0.51-0.77)	0.83 (0.74-0.93)	0.87 (0.76-1.00)	0.74 (0.63-0.87)
Cancer-directed surgery						
Yes	0.78 0.72-0.84)	0.79 (0.72-0.87)	0.72 (0.63-0.83)	0.91 (0.86-0.97)	0.95 (0.88-1.02)	0.82 (0.74-0.90)
No	0.71 0.66-0.77)	0.70 (0.64-0.75)	0.75 (0.65-0.87)	0.82 (0.77-0.88)	0.83 (0.77-0.90)	0.77 (0.68-0.86)

Note: NCI = National Cancer Institute; CI = confidence interval; SEER = Surveillance, Epidemiology, and End Results.

[a]Odds ratios were also adjusted for age at diagnosis, sex, race/ethnicity, rarality of residence, predominance of primary care prior to diagnosis, median household income for ZIP code of residence at diagnosis, SEER registry of residence at diagnosis, and the stratification factors (cancer type, stage, comorbidities, and surgery), except when stratified by that factor.

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Table 5

Comparison of Predictive Models of 1- and 3-Year Mortality as a Function of Hospital Attendance[a] in Medicare Beneficiaries With an Incident Diagnosis of Breast, Lung, Colon/Rectum, or Prostate Cancer as Identified in SEER-Medicare Data From 1998 to 2002

	Odds Ratio[b] (95% CI) for Mortality Measure Among NCI Cancer Center Attendees vs. Nonattendees					
	1-Year Mortality			3-Year Mortality		
Comparison Modeled	All-Cause	Cancer-Specific	Other-Cause	All-Cause	Cancer-Specific	Other-Cause
Odds of mortality with attendance at NCI cancer centers vs. specialty hospitals[c] *n* = 150,927	0.75 (0.71-0.80)	0.75 (0.71-0.80)	0.74 (0.66-0.82)	0.87 (0.83-0.91)	0.90 (0.85-0.95)	0.79 (0.74-0.86)
Odds of mortality with attendance at specialty hospitals vs. other hospitals *n* = 195,671	0.97 (0.94-1.01)	0.94 (0.91-0.98)	1.02 (0.97-1.08)	1.04 (1.01-1.07)	1.02 (0.99-1.06)	1.06 (1.02-1.11)
Odds of mortality with attendance at NCI cancer centers vs. other hospitals *n* = 75,498	0.74 (0.69-0.79)	0.72 (0.67-0.78)	0.74 (0.66-0.84)	0.92 (0.87-0.98)	0.95 (0.89-1.02)	0.84 (0.77-0.92)

Note: NCI = National Cancer Institute; CI = confidence interval; SEER = Surveillance, Epidemiology, and End Results.

[a] Attendance is defined as two or more claim days in the first 12 months after diagnosis.

[b] Odds ratios were adjusted for age at diagnosis, stage at diagnosis, sex, cancer type, race/ethnicity, surgery, rurality of residence, predominance of primary care prior to diagnosis, SEER registry of residence at diagnosis, comorbidities, and median household income for ZIP code of residence at diagnosis.

[c] Specialty hospital is defined as a teaching, referral, or American College of Surgeons Oncology Group (ACSOG)-accredited hospital, other than an NCI cancer center.