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Testing Cancer Quality Measures for End-of-Life Care

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Abstract

Background. The quality of end-of-life care for cancer has important deficiencies. There are two approaches to measuring this care: *retrospectively* prior to death, or *prospectively* for patients with a poor prognosis.

Objectives. To examine (1) the performance of existing "*retrospective*" quality indicators; (2) novel indicators for opiate analgesia and chemotherapy toxicity; and (3) whether patterns of use vary for *retrospective* and *prospective* approaches.

Data. Linked Medicare claims, pharmaceutical claims, and cancer registry data from 1994 - 2003 for New Jersey (NJ) and Pennsylvania (PA).

Subjects. Seniors with breast, colorectal, lung, or prostate cancer who participated in state pharmaceutical benefit programs for near-poor seniors.

Measures. Previously validated *retrospective* indicators, and new measures to reflect the use of opiate analgesia and chemotherapy toxicity.

Results. Use of chemotherapy and opiates were more common, but use of hospice was less common, in the *prospective* vs. *retrospective* cohort. In multivariate models, visit with a surgeon was positively associated with use of chemotherapy and opiates, toxicity, and negatively associated with hospice (*both* cohorts). Visit with an oncologist was positively associated with chemotherapy, opiates, and hospice. Patients cared for by oncologists in a small group practice were more likely to receive chemotherapy (*retrospective* only) and less likely to receive hospice (*both*) than those in a large group. Compared to patients cared for in teaching hospitals, those in other hospitals were more likely to receive chemotherapy (*both*) and have toxicity (*prospective*), but less likely to receive opiates (*both*) and hospice (*retrospective*).

Discussion. Several of the existing retrospective measures could be replicated in these data. New indicators for opiate use and toxicity appear feasible and potentially important. Retrospective and prospective measures identify some similar physician and hospital patterns of end-of-life care.

Introduction

While cancer causes more than a half million deaths each year in the United States (US),[1] little is known about the quality of end-of-life care. Initiatives to study the quality of cancer care have focused largely on initial treatment decisions.[2-5] Yet prior work on the quality of end-of-life care suggests several important deficiencies; many patients with advanced cancer continue to get aggressive chemotherapy, and may not receive hospice or other palliative care services.[6-8] Adequate pain control for patients dying from cancer has been highlighted as an area in particular need of improvement.[9] Prior work suggests that 25–70% of patients suffer from considerable pain at the end-of-life.[10-13] Hospice is also a fundamental part of end-of-life care for patients with cancer and has been associated with less suffering and better satisfaction than conventional hospital care.[11,14] Because hospice may improve the quality of life of patients at the end-of-life, Medicare has provided coverage for hospice services since 1983.[14,15] While the use of hospice care has been increasing over time, it remains broadly underutilized.[15-20] These findings suggest that there is much room for improvement in the quality of end-of-life care.

Quality measurement is the foundation for interventions and policies to improve the quality of care. Reliable and valid measures of the quality of end-of-life care are necessary to define targets for improvement.[21] Two approaches have been used to examine the quality of end-of-life care. Several studies have identified patients who have died and then have looked *retrospectively* at the care received during some time period prior to death.[6,22,23] The alternative approach is to identify patients who have a poor prognosis and then *prospectively* examine the care that they receive.[16,24] Because of the complexities of accurately predicting when a patient is approaching death,[25] the later approach may result in a less representative sample.[26] Conversely, retrospective studies do not include information about patients who are expected to die, but then recover, and may lead to biased estimates of utilization particularly when the time interval between diagnosis and death is longer.[27] Retrospective designs are efficient and provide information about care received in the period immediately prior to death, yet it is hard to use retrospective measures for quality improvement.

Prior claims based analyses have largely focused on the utilization of hospital-based services and hospice care.[6,22,23] Existing claims-based quality indicators have not included measures that include outpatient prescription drugs. As these claims become more available, it is appealing to develop measures for the use of opiate analgesia at the end-of-life. The adequate treatment of pain at the end-of-life is a cornerstone of end-of-life care,[12] and opiates are a central to these pain treatment regimens. As chemotherapy-related adverse effects (i.e., toxicity) may also be a more specific indicator of overly aggressive treatment near the end-of-life than the use of chemotherapy more broadly, this is also a potentially important indicator of quality of care at the end-of-life.

The purpose of this analysis is to further evaluate claims-based indicators of the quality of care at the end-of-life for seniors with cancer. Specifically, our goals were to: (1) Provide further data about the performance of existing *retrospective* quality indicators in new populations;[6,8] (2) Develop novel indicators of the quality of care at the end-of-life using outpatient pharmacy data to create benchmarks for the use of opiate analgesia and chemotherapy toxicity; and (3) Examine whether patterns of variation in benchmark utilization by physician and hospital characteristics is similar or different for *retrospective* and *prospective* measures.

Methods

Data Sources

Linked Medicare claims, pharmaceutical claims and cancer registry data for the period January 1, 1994 through May 31, 2003 were used for two states, New Jersey (NJ) and Pennsylvania (PA). Medicare Part A (hospitalization and nursing home stays), Part B (outpatient services and procedures), and patient enrollment data were linked with pharmaceutical claims from the NJ Pharmaceutical Assistance for the Aged and Disabled (PAAD) Program, and the PA Pharmaceutical Assistance Contract for the Elderly (PACE) Program, respectively.[28,29] Both the PAAD and PACE programs provide pharmaceutical benefits to near-indigent residents age 65 and older. PACE is the largest US state prescription benefits program for the elderly. PACE has no deductibles or maximum annual benefit and charges a modest co-payment of $6 for each generic prescription and $9 for brand name prescription. The current income ceiling for eligibility (2007) is $14,500 if single and $17,700 for a couple, resulting in a recipient population of both indigent and near-poor elderly (See http://www.aging.state.pa.us/aging/cwp/view.asp?a=554&Q=254019&agingNav=|6658| for additional information). The PAAD program is quite similar to PACE. There is no deductible, and a small co-payment of $5. The current (2007) income eligibility criterion for PAAD is an annual income between $22,752 and $27,676 for a married couple (See http://www.state.nj.us/health/seniorbenefits/paad.shtml). These generous benefits and requirements for financial need result in essentially no out-of-pocket (i.e., out-of-system) medication use. Eligibility is determined annually for both of these programs. Electronic pharmacy dispensing records from these programs are considered accurate because pharmacists fill prescriptions with little room for interpretation, and are reimbursed by insurers on the basis of detailed, complete, and accurate claims submitted in electronically.[30,31]

Health care and pharmaceutical claims for this population were further linked to the New Jersey State Cancer Registry (NJSCR) and the Pennsylvania Cancer Registry (PCR).[29] The NJCR is one of the population-based cancer registry programs that participate in the Surveillance, Epidemiology, and End Results (SEER) Program. The PCR is certified as "gold" (the highest quality) by the North American Association of Central Cancer Registries. Both cancer registries are population-based and collect data on patient demographics, primary tumor site, morphology, cancer stage at diagnosis, first course of treatment, and follow-up for vital status. The Brigham and Women's Hospital Institutional Review Board reviewed and approved this study.

Definition of Cohorts

Retrospective Cohort

The retrospective cohort includes patients with a primary diagnosis of primary breast, colorectal, lung, or prostate cancer who died during the study period. Patients included in this analysis were required to have at least one Medicare claim within 14 months prior to death and to have filled at least one prescription in each of two consecutive 7-month periods prior to death, to ensure continuous eligibility (and therefore complete data ascertainment) during the study period. The date of death was considered to be the index date in all retrospective cohort analyses. Data on cause of death was only available for patients from NJ (1994-2002). These individuals were examined as a subgroup of the retrospective cohort as prior benchmarks for end-of-life care have focused specifically on cancer-related deaths.[6,8]

Prospective Cohort

The goal of the prospective cohort was to identify individuals with these common cancers at higher risk of death. First, we identified all patients with a cancer registry-based primary diagnosis of breast, colorectal, lung, or prostate cancer and had at least one Medicare claim within the 14 months prior to and following cancer diagnosis and at least one PAAD/PACE pharmaceutical claim in each of two consecutive 7-month periods prior to and following cancer diagnosis. Eligibility for the prospective cohort was further restricted to those patients who had at least 14 months of claims data following their cancer diagnosis date (or until death if death occurred within the 14 month period). The date of cancer diagnosis was considered the index date for the prospective cohort.

We applied a prediction algorithm to the prospective cohort to identify three subgroups of patients with a higher probability of mortality (those with a 40-, 60-, and 80% probability of death within 14 months following cancer diagnosis). Patients were identified for these cohorts based on their predicted probability of death with logistic regression models using baseline characteristics including age (5-year age groups), gender, race (white, non-white), income category (<$25,000; 25,0000-49,999; 50,000-74,999, $\geq$ 75,000), primary cancer site, Charlson comorbidity score (continuous), histology type (e.g., ductal carcinoma, adenocarcinoma), cancer stage (in situ, localized, regional, distant, unknown), and presence of a metastasis to a solid organ (defined by the presence of an ICD9 diagnosis code 197.xx – 198.xx during a hospitalization or ED visit within 2 weeks of diagnosis). The c-statistics for these models ranged from 0. 78 - 0.83

Independent Variables

Patient Characteristics

Sociodemographic data (age, gender, race, zip code) were drawn from Medicare enrollment files. We matched each individual's zip code to the median household income using Census 2000 data to act as a proxy for socioeconomic status.[32] A comorbidity score was calculated for each patient using the algorithm defined by Charlson.[33] For each of the four cancers, we defined stage at diagnosis from cancer registry data as categorized above. In addition, Medicare claims were used to define distant spread of the cancer if a claim with these codes was apparent within 2 weeks of the cancer diagnosis. Cancer type was defined by SEER histology codes. Both cancer diagnosis date and death date were obtained from cancer registry data. Cause of death was available for NJ patients from a cause of death file, extracted from NJ death certificates.

Physician and Hospital Characteristics

For patients from Pennsylvania, Unique Provider Identification Numbers (UPINs) for each treating physician were linked with the 2003 American Medical Association (AMA) Masterfile. UPINS were only available in the Pennsylvania data. Using physician specialty codes, treating physicians were identified for each patient. For the prospective cohort, these were defined as the first surgeon, primary care physician, medical oncologist, and radiation oncologist following the cancer diagnosis date. For the retrospective cohort, these were defined as the last physician seen before death. We defined surgeons as those with one of the following primary or secondary specialties: colon and rectal surgery, surgical oncology, thoracic surgery, urology, general surgery, cardiothoracic surgery. Physicians who identified a specialty of hematology/oncology, oncology, or medical oncology were included as medical oncologists. Physicians who identified their specialty as radiation oncology were considered to be radiation oncologists. Primary care

physicians were identified by a specialty of family practices, general practice, general practice medicine, internal medicine, internal medicine geriatrics, and family practice geriatrics. Because oncologists are more directly responsible for prescribing and managing chemotherapy, we further categorized oncologists by gender, type of practice (defined as solo or 2-physician practice, group practice, hospital-based, medical school-based, and other which included government, HMO, and no classification), number of years since medical school graduation, and whether they were an international medical graduate (IMG). Of the UPINS represented in the outpatient claims from our patient population, 86% of the prospective cohort and 85% of the retrospective cohort matched the 2003 AMA Masterfile. Because our data included individuals with claims from 1994–2003, some of the physicians who were practicing in the earlier years may have retired by 2003.

For each patient in both Pennsylvania and New Jersey, we identified a treating hospital from Medicare Part A claims data. Treating hospital was defined as the first acute care hospital visited following the date of cancer diagnosis for the prospective cohort or the last hospital visited before death for the retrospective cohort. Characteristics for each hospital were defined from the 2003 American Hospital Association (AHA) file, including teaching status (defined as membership in the Council of Teaching Hospitals)[34] number of beds, ownership (for profit, non-profit), and whether the hospital had a surgical cancer program, provided chemotherapy services, or provided hospice or palliative care services. Additionally, we determined if the hospital was a National Cancer Institute (NCI)-designated cancer facility.[35]

Cancer End-of-Life Quality Benchmark Measures

We defined benchmark measures of quality of cancer care at the end-of-life using measures previously by Earle et al.[6,8,26] These included the proportion of patients who: a) received a chemotherapy regimen, b) received a new chemotherapy regimen, c) had > 1 emergency department (ED) visit, d) had > 1 hospitalization, e) had $\geq$ 1 admission to the intensive care unit (ICU), f) were not admitted to hospice, g) were admitted to hospice within 3 days of death, h) died in an acute care setting. These measures were constructed to identify health care systems that provide overly aggressive disease modifying therapies at the end-of-life.

As patients at the end-of-life may suffer from considerable pain,[10-13] new benchmark measures were also defined to reflect the appropriate use of opiate analgesia, including the proportion of patients who received an outpatient prescription for: i) a long-acting opiate, j) a short-acting or a long-acting opiate, or k) both a short-acting and a long-acting opiate. The creation of benchmarks for opiate analgesia is particularly timely as pharmacy claims for Medicare Part D become available. Finally, we examined the proportion of patients who had an ED visit or hospitalization related to chemotherapy toxicity. Chemotherapy toxicity may be an indicator that the risks of chemotherapy surpass the benefits.

Use of chemotherapy was defined using the codes listed in Table 1. Of note, our data did not include some of the codes used by Earle et al (HCPCS Q0083, Q0084, Q0085) and Revenue Center Codes (RCCs: 0331, 0332, 0335).[8] New chemotherapy regimen was defined only for the retrospective cohort using Medicare J-codes for drugs used by Earle.[8] Additional J-codes for chemotherapy were identified for chemotherapy drugs that had received FDA approval since the benchmarks were created (Appendix A). A new chemotherapy regimen was characterized as one, administered during the 30 days prior to death, which included a new drug or combination of drugs that had not been used previously within the study period (14 months prior to death). We did not examine the new chemotherapy benchmark for the prospective cohort as new chemotherapy is commonly given around the time of cancer diagnosis, and it therefore would not be a valid benchmark for end-of-life care. Visits to the ED, admission to the hospital, ICU, and

hospice, and death in an acute care setting were all identified using Medicare claims (Part A or hospice file). Prescriptions for the opiate analgesics were based on National Drug Codes (NDC) for both generic and brand opiates (Appendix B). We defined chemotherapy toxicity based International Classification of Diseases (ICD-9) codes and Diagnosis-Related Group (DRG) codes validated by Hassett et al.[36] A toxicity code needed to occur within 90 days of a chemotherapy claim to be considered a chemotherapy-related toxicity.

For the *prospective* cohort, benchmark measures were calculated for the 14 months following the date of cancer diagnosis (Figure 1a, period b) except for the benchmarks for chemotherapy toxicity and admission to hospice within 3 days of death. Chemotherapy toxicity was calculated for events that occurred between the receipt of the first chemotherapy regimen and the last chemotherapy regimen plus 90 days. Therefore, the denominator for this benchmark measure included only those patients who had chemotherapy within 14 months after diagnosis.

For the retrospective cohort, benchmark measures were calculated during the 30 days prior to death (Figure 1b, period c), except for the benchmarks for chemotherapy toxicity and admission to hospice within 3 days of death.[6-8] The chemotherapy toxicity benchmark was calculated from receipt of last chemotherapy regimen plus 90 days and truncated at date of death. Thus, chemotherapy toxicity could occur at any time during the 14 months period from diagnosis to death.

Data Analysis

We calculated the distribution (frequencies or means) of patient, physician, and hospital characteristics as well as each of the benchmark measures for each cohort. We also compared the prevalence of the benchmark measures in our retrospective cohort to those previously observed by Earle.[8] Because the population in Earle's study included gastric cancers, excluded prostate cancer, and had more males and younger patients, we excluded gastric cancer from Earle's original dataset and standardized the rates of their retrospective benchmark measures for the age, cancer type, and gender of our population. To compare the performance of the benchmarks between *prospective* cohorts and *retrospective* cohorts, we estimated the effect of physician and hospital characteristics on a subset of clinically important benchmarks: any opiate use (long or short-acting), not admitted to hospice, use of chemotherapy, and chemotherapy toxicity. For each benchmark, we developed a series of three multivariate logistic regression models: (1) a model that included only patient-level characteristics (patient model), (2) a model that included patient characteristics and physicians' characteristics (physician model), and (3) a model that included patient and hospital characteristics (hospital model). Each of these models adjusted for age, gender, race, income, primary site of cancer, Charlson score, cancer stage, and year of diagnosis. In addition, the patient models adjusted for whether a patient had a visit with surgeon, a medical oncologist, a radiation oncologist, and a visit with PCP. The physician models also adjusted for the gender of oncologist, the number of years since medical school graduation, whether the oncologist was an international medical graduate, and practice size and type. The hospital models also adjusted for whether the hospital was a NCI-designated cancer center, teaching status, number of hospital beds, profit status, and the presence of chemotherapy, and hospice or palliative care services. Because the data on physician characteristics are available only in the PA Medicare data and the data on cause of death is available only in NJ data, we could not build a single model with all three components. Generalized estimating equations were used to adjust for the clustering of patients within physicians and hospitals. Odds ratios with 95% confidence interval (95% CI) for each physician and hospital characteristic were summarized and compared among different cohorts. SAS for Windows software (release 9.2) was used for all statistical analyses (The SAS Institute, Cary, NC)

Results

Description of the Cohorts

We identified total of 33,675 patients for the prospective cohort and 32,810 patients in the retrospective cohort (Table 2). Compared with the full retrospective cohort, individuals in the full prospective cohort were younger, less likely to be male, and had a lower Charlson comorbidity score. The majority of individuals lived in a ZIP code with a median income less than $50,000. While there were income eligibility criteria for these programs, we did not have access to data about individual income and therefore used ZIP code medians as a proxy. In both cohorts, colorectal was the most common cancer, and prostate the least common. The median number of days between diagnosis and death was 539 days for the full-prospective cohort, and 1,053 days for the full retrospective cohort.

Within the prospective cohort, individuals with a higher predicted probability of death were older, more likely to be male, have lung cancer, and have later stage disease than individuals with a lower probability of death. The median number of days from diagnosis to death decreased from a median 539 days for the full cohort to 73 days for the sub-group with a predicted probability of death of > 80%.

Physician Characteristics

Among patients in both study cohorts, we identified those who had at least one physician visit and summarized the characteristics of their physicians, and in particular their oncologist (Table 3). Because physicians could not be identified in the NJ claims data, this analysis was restricted to PA patients. A PCP saw almost all patients, in both the retrospective and prospective cohorts, whereas only 46–62% were seen by medical oncologist. In the prospective cohort, the proportion of patients seen by a surgeon declined as the predicted probability of death increased, whereas the proportion seeing a medical or radiation oncologist increased. The characteristics of oncologist were similar in the different cohorts.

Hospital Characteristics

Among patients who had at least one hospitalization, approximately 40% of patients in both cohorts received care at an NCI-designated cancer facility and 20% were hospitalized at a teaching hospital (Table 4). The vast majority of care was provided at a non-profit facility. The majority of patients in all cohorts received care at a hospital with a surgical cancer center, chemotherapy services and hospice or palliative care services. These characteristics did not vary among the different cohorts, with the exception that individuals in the retrospective cohort who died from cancer were more likely to have had their last hospitalization at a hospital with a surgical cancer program or hospice/ palliative care services than individuals in the full retrospective cohort.

Prospective Benchmark Measures

Table 5 shows proportion of patients receiving our benchmark measures for end-of-life care in the *prospective* cohorts. Approximately one-quarter of these patients received chemotherapy, $1/4^{th}$ had > 1 ED visit, and $1/3^{rd}$ had > 1 hospitalization during the study period. The majority of patients were never admitted to hospice. Approximately one-quarter of patients were admitted to hospice within 3 days of death. Overall, use of long acting opiates, alone or in

combination with a short-acting opiate, was low (< 20% in all cohorts). Importantly, the occurrence of several of these benchmarks was similar across the cohorts defined by different levels of prognosis (i.e., use of chemotherapy, ED, hospital, ICU, death in a short term facility). Use of a long-acting opiates and hospice care was greater among those with a higher predicted probability of death. Similarly, the probability of chemotherapy toxicity was higher among those with a higher probability of death. For the majority of the benchmarks, there were temporal trends between 1994–2003; there were significant ($p < 0.001$) increases in chemotherapy use, ED and hospital use, hospice use (but also an increase in late hospice use and death in an acute care hospital), chemotherapy toxicity, and use of opiates.

Retrospective Benchmark Measures

Table 6 displays the prevalence rates for the benchmark measures for the *retrospective* cohorts as well as the standardized rates observed in the original cohort used by Earle et al.[8] The use of chemotherapy was higher among patients from NJ who died from cancer compared to the overall retrospective cohort, whereas admission to ICU and use of a long-acting opiate or hospice care were lower in the NJ cancer death cohort. The use of chemotherapy was substantially lower in these data compared with those observed in Earle's prior study, whereas higher utilization was observed for the measures of ED, hospital, and ICU usage. Admission to hospice within 3 days of death was more common in this sample than in Earle's prior analysis. The prevalence of the other benchmark measures was similar (i.e., use of a new chemotherapy regimen, death in a short term hospital, lack of hospice). Not surprisingly, the chemotherapy, ED use, lack of hospice, and hospital use benchmarks were more common in the prospective cohort (Table 5) than in the retrospective cohort (Table 6). Again for the majority of the benchmarks, there were temporal trends; there were significant ($p < 0.001$) increases in chemotherapy use, ED and hospital use, and hospice use (but also an increase in late hospice use and death in an acute care hospital); but a decline in opiate use.

Multivariate Models for Retrospective and Prospective Cohorts

Finally, Table 7 (parts a–d) shows how the effects of physician and hospital characteristics on selected benchmarks vary among the different cohorts, after adjustment for patient characteristics. For these analyses, we selected representative cohorts: two prospective cohorts (40% and 60% risk of death) and two retrospective cohorts (the full cohort and NJ cancer death cohort). Although the magnitude of the effects of physician and hospital characteristics on the receipt of the benchmark measures varied somewhat among different cohorts (especially between the prospective and the retrospective cohort), we found several similar patterns of effect on the benchmarks. Visit with a surgeon was positively associated with the receipt of chemotherapy (6a), the receipt of opiates (6b), the occurrence of chemotherapy toxicity (6c), and lack of admission to a hospice (6d) in both retrospective and prospective cohorts. Visit with a medical oncologist was independently associated with the receipt of chemotherapy, the receipt of opiates, and the occurrence of chemotherapy toxicity (prospective only, but was negatively associated with lack of admission to a hospice. The practice type of the treating oncologist was independently associated with several of the benchmarks. For example, patients cared for by oncologists who practiced in a small practice were more likely to receive chemotherapy (retrospective only), and lack admission to hospice (all cohorts) than patients receiving care in a group practice. Patients cared for by oncologists who practiced in a hospital-based practice were less likely to receive chemotherapy

(retrospective only), and less likely to receive opiates (retrospective only) than those cared for in a group practice. Patients receiving care in a non-teaching hospital were more likely to receive chemotherapy (prospective and retrospective), less likely to receive opiates (prospective and retrospective), more likely to have chemotherapy toxicity (prospective only), and more likely to lack hospice admission (retrospective only) compared to those cared for in a teaching hospital.

Several characteristics of the treating oncologist were not significantly associated with the occurrence of the benchmarks, including gender (except in one of the 2 prospective cohorts), years in practice since medical school graduation, and medical school location (US vs. international). Several hospital characteristics were also not associated with the benchmarks including whether the hospital was an NCI-designated cancer facility (except for opiate use in one of the two prospective cohorts), and hospital size (except for lack of admission to hospice and chemotherapy use in the NJ cancer death cohort).

Discussion

This work advances our understanding of the use of administrative data to assess the quality of end-of-life care for cancer patients in several ways. First, we demonstrate that Earle's previously developed measures are feasible in these new datasets with new populations. In some instances, differences between the databases precluded the exact definition of these prior measures (availability of information about cause of death, use of chemotherapy). Temporal changes were also demonstrated for several indicators. Second, the two new indicators of the quality of end-of-life care that we evaluated (use of opiate analgesia and chemotherapy toxicity) appear feasible and are worthy of further study. With the advent of Medicare Part D, outpatient pharmacy claims will increasingly become available in administrative data sets. In contrast to prior benchmarks, which have focused primarily on overuse of aggressive disease modifying therapy, this benchmark allows focus on the underuse of palliative care. While we do not know what the "appropriate" rate of opiate use should be in this population, prior work suggests that 25–70% of patients suffer from significant pain at the end-of-life.[10-13] Our work suggests that opiates were likely underused in this population. In addition, the prevalence of chemotherapy toxicity may be a more specific measure of overly aggressive treatment near the end-of-life than a general measure of chemotherapy use, as some use of chemotherapy may be appropriate particularly given the limitations of prognostication. Third, our work demonstrates that retrospective and prospective measures identify some similar physician and hospital patterns of end-of-life care. This provides some support to the use of retrospective measures for assessing the quality of end-of-life care.

Our work suggests that Earle's previously developed, retrospective measures are feasible in these data and raise similar conclusions about the quality of end-of-life care as his earlier work.[6,7] Similar to Earle's earlier work, our current study suggests that there is overuse of overly aggressive disease modifying therapies by some patients at the end-of-life, and under-use of palliative care. Several of the measures previously developed by Earle in a *retrospective* cohort of patients who died from cancer were observed at similar prevalence in our retrospective cohorts, including both those who died from cancer specifically as well as those who died but did not have a cause of death identified. Specifically, the rates of use of a new chemotherapy regimen, ICU care, hospice, and death in an acute care hospital were fairly similar. These indicators may be more consistent across populations, data sources, and time, and may therefore perhaps be more robust claims-based indicators of the end-of-life care. Of note our data are more recent than those used by Earle in his earlier work (1991–1996), and our data demonstrate temporal changes in the rates of many of these indicators.

Our work also suggests that these novel indicators of the quality of end-of-life care based on the use of opiate analgesia and chemotherapy toxicity are feasible and important. The adequate treatment of pain at the end-of-life is a cornerstone of end-of-life care.[12] Opiates are considered "essential" medicines for palliative care by the World Health Organization.[37] The Joint Commission on Accreditation of Healthcare Organizations requires screening and treatment for pain. Consistent with prior reports of the quality of care at the end-of-life, the use opiates, particularly long-acting opiates, was low.[38] While the prevalence of long-acting opiate use did increase with the predicted probability of death in the *prospective* cohort, use was < 20% even among those patients with a predicted probability of death of over 80% over the next 14 months. This rate was similar in the *retrospective* cohort. These findings confirm that the use of opiate analgesia for patients at the end-of-life can uniformly be improved as prior work suggests that 25–70% of these patients suffer from significant pain,[10-13] although it is unknown what percentage of patients at the end-of-life should ideally be using opiates. While the original qualitative research done by Earle to determine potential measures of the quality of end-of-life care identified the importance of including measures of pain control, these measures were not included in his earlier work because they would not be measured in SEER Medicare data.[7] The advent of Part D, with the resultant claims for outpatient prescriptions makes the examination of this measure particularly timely. Our measure of chemotherapy toxicity may be a more specific measure of over-zealous chemotherapy use near the end-of-life. In the prospective cohort, the prevalence of this indicator increased with the predicted probability of death, whereas the overall prevalence of chemotherapy use was fairly constant.

Finally, our work suggests that for selected benchmark measures *retrospective* and *prospective* approaches identify some similar physician and hospital patterns of end-of-life care. While *retrospective* measures can accurately reflect the care of those who have died, they are hard to actualize for ongoing quality improvement initiatives.[27,39] Although *prospective* measures are limited by the innate difficulties of accurately predicting prognosis, these indicators more accurately reflect the care that is being delivered at the end-of-life and are therefore more amenable to quality improvement initiatives. Measures of the quality of end-of-life care can be divided into those that measure over-use of aggressive care (chemotherapy, acute care hospital services), and those that measure under-use of palliative and supportive services (hospice, opiates).[7] While indicators for end-of-life care based on aggressive disease modifying cancer care are conceptually appropriate benchmarks for a *retrospective* cohort, they are more problematic for a *prospective* cohort, as most patients with a new diagnosis of cancer can be expected to receive a trial of chemotherapy or acute care services no matter how somber their prognosis.[7] Measures focused on underuse, however, are conceptually relevant for both *prospective* and *retrospective* cohorts. While we were able to look at broad categories of physician and hospital characteristics (e.g., practice type, teaching status), future work should examine the performance of these measures for specific physicians and hospitals.

While our measures should be validated in other settings and using clinical data, several measures are worthy of further study. In particular, the use of opiates and monitoring for toxicity from chemotherapy seem particularly relevant to prospective quality improvement. Initiatives to prospectively improve the quality of end-of-life care will also need to focus on interventions to help physicians more accurately estimate prognosis, and educate patients and their families about prognosis and end-of-life treatment options.[25,40,41] The dissemination of electronic medical records may also facilitate the documentation of pain as well as preferences for end-of-life care. Even if the utility of these prospective measures is confirmed in future study, it will also be important to

assess whether these indicators are associated with the satisfaction of patients and their families for end-of-life care.[42]

Our work has several limitations. Some of Earle's prior measures could not be replicated exactly in our data. Importantly, data about cause of death was only available in these data for one of the two states that we included in our analysis. Linkage to other data sources, for example the National Death Index, could make up for a lack of this information in future analyses. Additionally, some of the specific codes used to define chemotherapy by Earle were not present in these data. Reanalysis of Earle's earlier data shows that 11.3% of chemotherapy use was defined by these particular codes. In a review of the accuracy of the prior benchmarks, Earle et al. found that chemotherapy claims showed lower accuracy (compared with medical records) than other benchmarks.[8] However, the difference in the rate of chemotherapy may also be due to the difference in the population, especially as our population includes lower income elderly who may be frailer. The physician information was only available in one of the two states. We therefore could not examine physician and hospital effects simultaneously. We used 2003 data to define hospital and physician characteristics because of data availability. This may have lead to misclassification in some cases. Finally, our data are limited to disadvantaged elders who participated in the pharmacy benefit programs of two mid-Atlantic states, further work should examine these indicators in broader populations. Approximately half of the states have had pharmacy assistance programs like the ones used in this project. We did not have access to individual income data, but rather relied on census tract-proxy data.[32]

This work highlights the complexities of measuring the quality of care at the end-of-life. It suggests that measures of under-use may be more generalizable across end-of-life cohorts than measures of overuse. Among measures of overuse, those that more specifically identify overly aggressive disease modifying therapies (toxicity, new regimens) may be more generalizable than those that look at usage patterns for more common indicators of care (e.g., use of hospital, ED). Measures of under-use of palliative services may be more "actionable" from the perspective of ongoing quality improvement initiatives. These data also suggest that while retrospective measures are not ideal for quality improvement, that they may be useful to identify populations who may benefit from quality improvement initiatives.

Translation of Findings

This work confirms the overuse of aggressive disease modifying therapies at end-of-life and underutilization of palliative services. Several factors may contribute to problems in the delivery of end-of-life care for patients with cancer, including fragmented care systems with limited communication between primary care providers and specialists, inaccurate assessment of prognosis by providers and patients, limited communication about this difficult topic between providers and patients, and limited resources for hospice and palliative services. The translation of this work on assessing prospective and retrospective benchmarks for end-of-life care suggest that further work should be done to improve the quality of end-of-life care prospectively. This may include:

- Better definition by professional societies to define guidelines to describe the minimum benefit necessary for a treatment to be recommended or continued.[43]
- A change of financial incentives. Oncologists receive greater reimbursement for providing chemotherapy than for counseling patients and their families about prognosis and treatment options.
- Tools to help educate patients and their families about the risks and benefits of treatments at the end-of-life.

- The development and validation of symptom measurement tools to guide the treatment recommendations of physicians caring for patients at the end-of-life.[44]

Future work should be done to examine these prospective benchmarks across systems of care, in other patient populations, and before and after quality improvement initiatives.

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Tables and Figure

Table 1. Definition of the benchmark measures

Benchmark	Definition	Data Source	Codes
Any chemotherapy	Numerator: Individuals with documentation of ≥ 1 of the specified codes. Denominator: All subjects Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• Medicare claims	• HCPCS (J7150, J8999, J8500-J8799, J9000-J9999) • CPT codes (96400, 96408, 96410, 96412, 96414, 96545, 96549) • ICD9 diagnosis (V58.1, E933.1, E930.7) and procedure (99.25) codes • DRG (410).
New chemotherapy regimen	Numerator: Individuals with documentation of ≥ 1 of the specified codes. Denominator: All subjects (did they have to receive some prior chemo during the prior 14 months? Reference period: *Prospective:* Not defined for this cohort. *Retrospective*: Occurred during the 30 days prior to death and not during the preceding 14 months.	• Medicare claims	Medicare J codes used by Earle (8) and supplemented by those listed in Appendix A.
> 1 emergency department (ED) visit	Numerator: Individuals with documentation of > 1 ED visit Denominator: All subjects Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• Medicare claims	
> 1 hospitalization	Numerator: Individuals with documentation of > 1 hospital stay Denominator: All subjects Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• Medicare claims	
≥ 1 admission to the intensive care unit (ICU)	Numerator: Individuals with documentation of ≥ 1 ICU stay Denominator: All subjects Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• Medicare claims	Revenue Center Codes (0200, 0201, 0202, 0209)
Not admitted to hospice	Numerator: Individuals without documentation of hospice care Denominator: Prospective: All subjects with an index date on or after January 1st 1997. Retrospective: All patients with 14 months of data (prior to index date) after January 1st 1997. Prospective: 14 months following cancer diagnosis. Retrospective: 30 days prior to death.	• Medicare claims	
Admitted to hospice within 3 days of death	Numerator: Individuals with documentation of hospice care within 3 days of death Denominator: Subjects who died who had some hospice care Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• Medicare claims	
Death in an acute care setting	Numerator: Individuals with documentation of a discharge status of death from an acute care hospitalization Denominator: All subjects who died. Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• Medicare claims	

Benchmark	Definition	Data Source	Codes
Received an outpatient prescription for a long-acting opiate	Numerator: Individuals with documentation of ≥ 1 of the specified codes. Denominator: *Prospective:* Subjects with at least 9 months out of the hospital during the 14 months follow-up. *Retrospective:* Subjects with at least 20 days out of the hospital during the 30 days of follow-up. Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• PACE/ PAAD	NDC codes for drugs listed in Appendix 2.
Received an outpatient prescription for a short-acting or a long-acting opiate	Numerator: Individuals with documentation of ≥ 1 of the specified codes. Denominator: *Prospective:* Subjects with at least 9 months out of the hospital during the 14 months follow-up. *Retrospective:* Subjects with at least 20 days out of the hospital during the 30 days of follow-up. Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• PACE/ PAAD	NDC codes for drugs listed in Appendix 2.
Received an outpatient prescription for) both a short-acting and a long-acting opiate.	Numerator: Individuals with documentation of ≥ 1 of the specified codes. Denominator: *Prospective:* Subjects with at least 9 months out of the hospital during the 14 months follow-up. *Retrospective:* Subjects with at least 20 days out of the hospital during the 30 days of follow-up. Reference period: *Prospective:* 14 months following cancer diagnosis. *Retrospective*: 30 days prior to death.	• PACE/ PAAD	NDC codes for drugs listed in Appendix 2.
Proportion of patients who had an ED visit or hospitalization related to l) chemotherapy toxicity	Numerator: Individuals with an ED visit or hospitalization with documentation of ≥ 1 of the specified codes within 90 days of chemotherapy code. Denominator: All subjects with documented chemotherapy (as above) over 14-month period. Reference period: Calculated from receipt of last chemotherapy regimen plus 90 days and truncated at date of death.	• Medicare claims	ICD-9 diagnosis codes DRGs (36) Codes are documented in Appendix C.

Table 2. Baseline characteristics of the combined Pennsylvania and New Jersey (NJ) cancer registry patients, prospective and retrospective cohorts

	Prospective Cohort				Retrospective Cohort			
	Full Cohort	**P(Death) > 40%**	**3: P(Death) > 60%**	**P(Death) > 80%**	**Full Cohort**	**NJ cancer deaths[e]**	**NJ non-cancer deaths[e]**	**PA Cohort**
	N (%) or mean ± SD, unless otherwise noted							
Patient characteristics[a, b]								
N patients	33,675	9,065	6,097	3,252	32,810*	4,945	3,753	18,245
Age								
65 – 69	3,629 (10.8)	754 (8.3)	487 (8.0)	216 (6.6)	1,979 (6.0)	493 (10.0)	127 (3.4)	978 (5.4)
70 – 74	7,134 (21.2)	1,543 (17.0)	998 (16.4)	501 (15.4)	4,320 (13.2)	835 (16.9)	331 (8.8)	2477 (13.6)
75 – 79	8,964 (26.6)	2,326 (25.7)	1,589 (26.1)	832 (25.6)	6,997 (21.3)	1,242 (25.1)	633 (16.9)	3943 (21.6)
80 – 84	7,552 (22.4)	2,130 (23.5)	1,482 (24.3)	800 (24.6)	7,938 (24.2)	1,120 (22.7)	908 (24.2)	4509 (24.7)
85+	6,396 (19.0)	2,312 (25.5)	1,541 (25.3)	903 (27.8)	11,576 (35.3)	1255 (25.4)	1,754 (46.7)	6338 (34.7)
Male gender	11,437 (34.0)	3,230 (35.6)	2,268 (37.2)	1,254 (38.6)	12,520 (38.2)	1,911 (38.7)	1,589 (42.3)	6605 (36.2)
White race	29,780 (88.4)	8,141 (89.8)	5,470 (89.7)	2,930 (90.1)	29,362 (89.5)	4,087 (82.7)	3,201 (85.3)	17057 (93.5)
Income[d]								
< $25000	1,882 (5.6)	618 (6.8)	405 (6.6)	211 (6.5)	1,955 (6.0)	230 (4.7)	145 (3.9)	1365 (7.5)
$25000 - $49999	20,047 (59.5)	5,956 (65.7)	4,095 (67.2)	2,223 (68.4)	20,796 (63.4)	2,129 (43.1)	1,606 (42.8)	14657 (80.3)
$50000 - $74999	9,140 (27.1)	1,984 (21.9)	1,272 (20.9)	639 (19.7)	7,941 (24.2)	1,985 (40.1)	1,527 (40.7)	1943 (10.7)
$75000 +	2,191 (6.5)	388 (4.3)	246 (4.0)	140 (4.3)	1,725 (5.3)	524 (10.6)	427 (11.4)	108 (0.6)
Unknown	415 (1.2)	119 (1.3)	79 (1.3)	39 (1.2)	393 (1.2)	77 (1.6)	48 (1.3)	172 (0.9)
Primary cancer site								
Breast	9,932 (29.5)	393 (4.3)	204 (3.4)	66 (2.0)	8,237 (25.1)	900 (18.2)	1,120 (29.8)	4663 (25.6)
Colon	10,322 (30.7)	2,050 (22.6)	1,047 (17.2)	416 (12.8)	9,810 (29.9)	1,350 (27.3)	1,215 (32.4)	5546 (30.4)
Lung	7,529 (22.4)	6,425 (70.9)	4,743 (77.8)	2,731 (84.0)	8,627 (26.3)	2,034 (41.1)	388 (10.3)	4899 (26.9)
Prostate	5,892 (17.5)	197 (2.2)	103 (1.7)	39 (1.2)	6,136 (18.7)	661 (13.4)	1,030 (27.4)	3137 (17.2)
Charlson comorbidity score	3.46 ± 2.92	5.50 (± 3.35)	5.88 (± 3.40)	6.75 (± 3.38)	7.35 ± 3.1	8.08 ± 2.9	6.81 ± 3.3	7.26 ± 3.0

	Prospective Cohort				Retrospective Cohort			
	Full Cohort	**P(Death) > 40%**	**3: P(Death) > 60%**	**P(Death) > 80%**	**Full Cohort**	**NJ cancer deaths[e]**	**NJ non-cancer deaths[e]**	**PA Cohort**
Death by cancer class (death within 14 months in prospective cohort)								
Breast	888 (9.7)	222 (3.5)	128 (2.7)	52 (1.8)	1,009 (9.6)	160 (7.2)	104 (15.1)	615 (10.3)
Colon	2,705 (29.5)	1,278 (20.1)	779 (16.1)	343 (12.1)	2,874 (28.4)	564 (25.5)	275 (39.9)	1726 (28.8)
Lung	5,046 (55.1)	4,733 (74.6)	3,848 (79.7)	2,412 (85.0)	5,606 (55.3)	1,405 (63.6)	194 (28.2)	3287 (54.8)
Prostate	524 (5.7)	114 (1.8)	74 (1.5)	31 (1.1)	650 (6.4)	82 (3.7)	116 (11.3)	370 (6.2)
Death by cancer stage at diagnosis (death within 14 months in prospective cohort)								
Localized	1,886 (20.6)	560 (8.8)	151 (3.3)	17 (0.6)	1,937 (19.1)	260 (11.8)	243 (35.3)	1200 (20.0)
Regional	2,317 (25.3)	1,312 (20.7)	730 (15.1)	149 (5.3)	2,595 (25.6)	567 (25.6)	195 (28.3)	1501 (25.0)
Distant	3,785 (41.3)	3,646 (57.4)	3,394 (70.3)	2,522 (88.9)	4,298 (42.4)	1,113 (50.3)	116 (16.8)	2442 (40.7)
Unknown	1,035 (11.3)	816 (12.9)	550 (11.4)	148 (5.2)	1,180 (11.6)	261 (11.8)	109 (15.8)	779 (13.0)
Days to death, median (interquartile range)[c]	539 (1,253)	158 (383)	110 (281)	73 (189)	1,053 (2,040)	970 (1337)	1,687 (2148)	951 (1887)
Metastasized to solid organs	3,185 (9.5)	2,628 (29.0)	2,286 (37.5)	1,686 (51.9)	12,793 (39.0)	3,126 (63.2)	401 (10.7)	7127 (39.1)

[a]Most baseline characteristics for patients in the prospective cohort were determined during the 14 months prior to diagnosis date except metastasized cancers were defined in the two weeks post diagnosis date.

[b] Baseline characteristics for patients in the retrospective cohort were determined during the 14 months prior to death date.

[c]For the prospective cohort, this calculation is based only those that died within 14 months of diagnosis.

[d] Income was approximated using 2000 census data for the median household income for the zip code of residence at the time of diagnosis.

[e]Cause of death in NJ was only available through 2002. Full cohort also includes 5,867 patients who had missing cause of death.

P(death), probability of death; ICU, intensive care unit; Rx, prescription

Table 3. Characteristics of physicians and medical oncologists, prospective and retrospective cohorts, Pennsylvania

	Prospective Cohort, Pennsylvania				Retrospective Cohort, Pennsylvania
	Full Cohort	**P(Death) > 40%**	**P(Death) > 60%**	**P(Death) > 80%**	**PA cohort**
			N(%)		
Physician characteristics					
N patients	14,802	5,044	3,469	1,908	17,947
Patient visits[a]:					
Surgeon	12,031 (81.3)	3,133 (62.1)	2,004 (57.8)	1,033 (54.1)	12,815 (71.4)
Medical oncologist	7,052 (47.6)	2,836 (56.2)	2,018 (58.2)	1,180 (61.8)	8,294 (46.2)
Radiation oncologist	4,844 (32.7)	1,904 (37.8)	1,351 (38.9)	753 (39.5)	4,910 (27.4)
Primary care physician (PCP)	14,428 (97.5)	4,931 (97.8)	3,394 (97.8)	1,870 (98.0)	17,670 (98.5)
PCP only	1,129 (7.6)	697 (13.8)	509 (14.7)	279 (14.6)	2,721 (15.2)
PCP & medical oncologist	6,930 (46.8)	2,790 (55.3)	1,983 (57.2)	1,162 (60.9)	8,198 (45.7)
Medical Oncologist characteristics[b]					
N patients with an oncologist	7,052	2,836	2,018	1,180	8,294
Male	6,154 (87.3)	2,515 (88.7)	1,798 (89.1)	1,048 (88.8)	7,317 (88.2)
Years since medical school	22.0 (±7.9)	21.9 (±7.9)	21.8 (±8.0)	21.7 (±8.1)	22.6 (±8.0)
Medical school					
U.S.	4,458 (63.2)	1,781 (62.8)	1,286 (63.7)	747 (63.3)	5,111 (61.6)
Foreign	2,581 (36.6)	1,049 (37.0)	726 (36.0)	428 (36.3)	3,147 (37.9)
Type of Practice					
Solo or 2-physician practice	1,597 (22.7)	661 (23.3)	467 (23.1)	258 (21.9)	1,928 (23.3)
Group practice	3,550 (50.3)	1,446 (51.0)	1,023 (50.7)	612 (51.9)	4,237 (51.1)
Hospital-based	539 (7.6)	180 (6.4)	123 (6.1)	67 (5.7)	482 (5.8)
Medical school based	237 (3.4)	98 (3.5)	71 (3.5)	46 (3.9)	297 (3.6)
Other	1,126 (16.0)	451 (15.9)	334 (16.6)	197 (16.7)	1,350 (16.3)

[a]Visits were captured over a period of 14 months prospectively or 14 months retrospectively depending on the cohort.
[b]Defined as the 1st oncologist visit for the prospective cohort and the last for the retrospective cohort.

Table 4. Hospital characteristics, prospective and retrospective cohorts

	Prospective Cohort[a]				Retrospective Cohort[a]		
	Full Cohort	**P(Death) > 40%**	**3: P(Death) > 60%**	**P(Death) > 80%**	**Full Cohort**	**NJ cancer deaths**	**PA Cohort**
	N (%) or mean ± SD, unless otherwise noted						
N patients with an acute care hospitalization	12,105	3,541	2,351	1,228	9,790	2,122	5,688
NCI-designated cancer facility[b]							
NCI	5,031(41.6)	1,448 (40.9)	979 (41.6)	513 (41.8)	3,978 (40.6)	1,117 (52.6)	1,798 (31.6)
Other facility	7,074 (58.4)	2,093 (59.1)	1,372 (58.4)	715 (58.2)	5,812 (59.4)	1,005 (47.4)	3,890 (68.4)
Teaching hospital (COTH)[c]							
COTH	2,667 (22.0)	739 (20.9)	461 (19.6)	244 (19.9)	1,731 (17.7)	402 (18.9)	948 (16.7)
Other hospital	9,438 (78.0)	2,082 (79.1)	1,890 (80.4)	984 (80.1)	8,059 (82.3)	1,720 (81.1)	4,740 (83.3)
Hospital beds	203.1 (±160.9)	195.9 (±153.2)	194.3 (±149.6)	195.3 (±154.6)	187.7 (±141.8)	223.0 (±149.0)	158.1 (±118.1)
Ownership							
Non-profit	11,937 (98.6)	3,493 (98.6)	2,320 (98.7)	1,211 (98.6)	9,637 (98.4)	2,100 (99.0)	5,566 (97.9)
For profit	168 (1.4)	48 (1.4)	31 (1.3)	17 (1.4)	153 (1.6)	22 (1.0)	122 (2.1)
Surgical cancer program	8,506 (70.3)	2,395 (67.6)	1,611 (68.5)	838 (68.2)	6,527 (66.7)	1,561 (73.6)	3,470 (61.0)
Chemotherapy services	10,156 (83.9)	2,960 (83.6)	1,963 (83.5)	1,020 (83.1)	8,150 (83.3)	1,834 (86.4)	4,589 (80.7)
Hospice or palliative care services	7,577 (62.6)	2,184 (61.7)	1,455 (61.9)	757 (61.6)	5,808 (59.3)	1,340 (63.2)	3,165 (55.6)

[a]The assigned hospital was identified as the first acute care hospitalization within 14 months for the prospective cohort and the last acute care hospitalization within 30 days prior to death for the retrospective cohort.
[b]Identified from the National Cancer Institute website http://cancercenters.cancer.gov/cancer_centers/cancer-centers-names.html
[c]A list of U.S. teaching hospitals can be found at http://services.aamc.org/memberlistings/index.cfm?fuseaction=home.search&search_type=TH&state_criteria=ALL
NCI, National Cancer Institute; COTH, Council of Teaching Hospitals

Table 5. Benchmarks measured in the prospective cohort[a]

	Prospective Cohort			
	Full Cohort	**P(Death) > 40%**	**3: P(Death) > 60%**	**P(Death) > 80%**
	N (%) or mean ± SD, unless otherwise noted			
N patients	33,675	9,065	6,097	3,252
Received chemotherapy regimen	8,350 (24.8)	2,364 (26.1)	1,614 (26.5)	817 (25.1)
> 1 emergency department visit	8,285 (24.6)	2,791 (30.8)	1,779 (29.2)	899 (27.6)
> 1 hospital admission	10,130 (30.1)	3,267 (36.0)	2,069 (33.9)	1,012 (31.1)
Admitted to the ICU	4,904 (14.6)	1,505 (16.6)	863 (14.2)	390 (12.0)
Rx of a long-acting opiate[b]	3,037 (9.1)	1,426 (15.9)	1,028 (17.0)	521 (16.1)
Rx of a short-acting opiate[b]	14,128 (42.3)	3,963 (44.1)	2,602 (43.0)	1,311 (40.5)
Rx of a short or long-acting opiate[b]	14,758 (44.1)	4,227 (47.0)	2,808 (46.4)	1,425 (44.0)
Rx of a short and long-acting opiate[b]	2,407 (7.2)	1,162 (12.9)	822 (13.6)	407 (12.6)
Not admitted to hospice[e]	22,526 (88.7)	4,794 (68.5)	3,078 (64.8)	1,580 (61.2)
Admission to hospice ≤ 3 days of death[f]	758 (26.4)	576 (26.1)	439 (26.2)	280 (27.9)
Death in a short-term hospital setting[c]	2,864 (31.3)	1,832 (28.9)	1,388 (28.7)	806 (28.4)
Chemotherapy toxicity[d]	2,825 (33.8)	1,298 (54.9)	928 (57.4)	482 (58.9)

[a]With the exception of chemotherapy toxicity and admission to hospice within 3 days of death, all benchmarks were measured in the 14 months following the diagnosis date
[b]The denominator for opiate use limited to patients with at least 9 months out of hospital.
[c]The denominator for death in a short-term hospital includes only those patients who have died within 14 months of diagnosis.
[d]Chemotherapy toxicity was calculated between the receipt of the first chemotherapy regimen and the last chemotherapy regimen plus 90 days. The denominator for toxicity was limited to those that received chemotherapy:
[e]The denominator for lack of admission to hospice was patients with a diagnosis after December 31,1996.
[f]The denominator for admission to hospice within 3 days of death was patients with a death date after January 3, 1997.
P(death), probability of death; ICU, intensive care unit; Rx, prescription.

Table 6. Benchmarks measured for the retrospective cohorts[a]

	Retrospective cohort				
	Full Cohort	**PA cohort**	**NJ cancer deaths [e]**	**NJ cancer deaths [e] excluding prostate cancer**	**Earle et al. Standardized rates [f]**
	N (%) or mean ± SD, unless otherwise noted				
N patients	32,810	18,245	4,945	4,284	44,402
Received chemotherapy regimen	2,136 (6.5)	1,002 (5.5)	566 (11.5)	487 (11.4)	12,211(27.5)
Started a new chemotherapy regimen	258 (0.8)	153 (0.8)	80 (1.6)	68 (1.6)	488 (1.1)
> 1 emergency department visit	3,342 (10.2)	1726 (9.5)	420 (8.5)	357 (8.3)	3,375 (7.6)
> 1 hospital admission	4,443 (13.5)	2,444 (13.4)	554 (11.2)	466 (10.9)	2,886 (6.5)
Admitted to the ICU	4,016 (12.2)	2,145 (11.8)	412 (8.3)	362 (8.5)	3,641 (8.2)
Rx of a long-acting opiate[b]	2,175 (10.1)	1,248 (10.2)	495 (15.0)	423 (14.7)	
Rx of a short-acting opiate[b]	4,411 (20.5)	2,780 (22.7)	896 (27.2)	773 (26.9)	
Rx of a short or long-acting opiate[b]	5,277 (24.6)	3,275 (26.7)	1,056 (32.0)	910 (31.7)	
Rx of a short and long-acting opiate[b]	1,309 (6.1)	753 (6.1)	335 (10.2)	286 (10.0)	
Not admitted to hospice[c]	15,837 (65.8)	7,797 (65.7)	1,858 (53.4)	2,623 (87.0)	28,328 (63.8)
Admission to hospice ≤ 3 days of death[d]	2,375 (28.8)	1,119 (27.5)	449 (27.7)	141 (35.9)	5,683 (12.8)
Death in a short-term hospital setting	9,865 (30.1)	5,495 (30.1)	1,112 (22.5)	964 (22.5)	11,944 (26.9)
Chemotherapy toxicity[d]	3,784 (46.1)	1,839 (43.5)	872 (48.4)	686 (47.5)	

[a]With the exception of chemotherapy toxicity and admission to hospice within 3 days of death, all benchmark measures were calculated during the 30 days before death.
[b]The denominator for opiate use was patients with at least 20 days out of hospital.
[c]The denominator for lack of admission to hospice was patients with a death date after January 30, 1997.
[d]The denominator for admission to hospice within 3 days of death was patients with a death date after January 3, 1997.
[e]Cause of death in NJ was only available through 2002.
[f]Rate from Earle et al were standardized according to the distribution of age, gender, and cancer type in the cohort defined as "NJ cancer deaths excluding prostate cancer." Note that GI cancers were dropped in the standardization of the rates because they were not included in our study.
P(death), probability of death; ICU, intensive care unit; Rx, prescription.

Table 7a. Association of physician and hospital characteristics on the receipt of chemotherapy

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Patient[a]	Total number of patients (N)	5,044	3,464	17,947	
	Visit with: Surgeon	2.00*** (1.69,2.37)	2.04*** (1.68,2.47)	1.42*** (1.19,1.69)	
	Visit with Medical Oncologist	7.38*** (5.98,9.11)	7.71*** (5.97,9.95)	4.25*** (3.60,5.02)	
	Visit with Radiation Oncologist	1.62*** (1.37,1.91)	1.46*** (1.20,1.77)	1.02 (0.88,1.18)	
	Visit with Primary Care Physician	2.09** (1.05,4.16)	1.16 (0.58,2.32)	1.37 (0.69,2.75)	
Physician[b]	Total number of patients (N)	2,830	2,008	8,294	
	Oncologist gender (male)	0.98 (0.72,1.33)	1.04 (0.72,1.51)	0.94 (0.73,1.22)	
	Oncologist years since medical school:				
	10 -19 vs. under 10 years	0.83 (0.56,1.25)	0.97 (0.61,1.55)	1.14 (0.76,1.70)	
	20 - 29 vs. under 10 years	1.01 (0.68,1.49)	1.15 (0.73,1.82)	1.17 (0.77,1.77)	
	> 30 vs. under 10 years	0.93 (0.60,1.45)	1.14 (0.68,1.93)	1.21 (0.77,1.89)	
	Oncologist medical school:				
	Unknown vs. US	Not included in this model	Not included in this model	1.10 (0.48,2.49)	
	Foreign vs. US	1.07 (0.88,1.31)	1.04 (0.82,1.31)	1.09 (0.90,1.32)	

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Physician[b]	Oncologist practice:				
	Small vs. group practice	1.30** (1.02,1.65)	1.29* (0.97,1.72)	0.92 (0.72,1.18)	
	Hospital based vs. group practice	0.83 (0.58,1.20)	0.91 (0.62,1.35)	0.63** (0.43,0.92)	
	Medical school vs. group practice	0.76 (0.44,1.33)	0.83 (0.46,1.51)	0.56*** (0.37,0.83)	
	Other vs. group practice	1.35** (1.05,1.72)	1.30** (0.97,1.73)	1.10 (0.84,1.43)	
Hospital[c]	Total number of patients (N)	3,541	2,350	9,790	2,102
	Not an NCI designated cancer facility	1.02 (0.85,1.24)	1.03 (0.82,1.30)	1.06 (0.87,1.29)	0.99 (0.70,1.38)
	Not COTH	1.39** (1.05,1.83)	1.41** (1.04,1.90)	1.54*** (1.20,1.99)	1.38 (0.90,2.12)
	Number of hospital beds:				
	101 – 149 vs. < 100 beds	1.02 (0.82,1.27)	1.06 (0.80,1.41)	1.06 (0.80,1.41)	1.31 (0.80,2.16)
	150 – 249 vs. <100 beds	0.97 (0.75,1.28)	1.00 (0.72,1.39)	1.27* (0.97,1.67)	1.88** (1.17,3.02)
	≥250 vs. <100 beds	1.08 (0.81,1.45)	1.11 (0.79,1.56)	1.27* (0.96,1.67)	1.50* (0.89,2.53)
	For profit vs. nonprofit hospital	0.46 (0.18,1.16)	0.48 (0.18,1.30)	0.97 (0.60,1.58)	
	No surgical cancer program	0.79** (0.65,0.95)	0.72** (0.57,0.91)	0.90 (0.73,1.11)	0.87 (0.63,1.20)
	No chemotherapy services	1.15 (0.89,1.48)	1.14 (0.85,1.55)	0.98 (0.78,1.24)	0.60 ** (0.38,0.97)
	No hospice or palliative care services	1.09 (0.89,1.33)	1.18 (0.93,1.49)	1.04 (0.86,1.26)	1.16 (0.88,1.53)

Table 7b. Association of physician and hospital characteristics on the use of opiates (long or short-acting)

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Patient[a]	Total number of patients (N)	5,009	3,443	11,990	
	Visit with: Surgeon	1.59*** (1.40,1.81)	1.57*** (1.35,1.82)	1.22*** (1.11,1.34)	
	Visit with Medical Oncologist	1.50*** (1.32,1.70)	1.43*** (1.23,1.67)	1.31*** (1.19,1.44)	
	Visit with Radiation Oncologist	1.61*** (1.42,1.84)	1.76*** (1.51,2.05)	1.31*** (1.19,1.45)	
	Visit with Primary Care Physician	1.18 (0.80,1.76)	1.10 (0.69,1.75)	1.23 (0.90,1.70)	
Physician[b]	Total number of patients (N)	2,814	1,999	5,385	
	Oncologist gender (male)	0.89 (0.70,1.13)	0.82 (0.61,1.10)	0.98 (0.82,1.17)	
	Oncologist years since medical school:				
	10 - 19 vs. < 10 years	1.38 (0.94, 2.04)	1.37 (0.86,2.20)	1.11 (0.84,1.47)	
	20 - 29 vs. < 10 years	1.40* (0.95,2.04)	1.48* (0.93,2.35)	1.10 (0.82,1.47)	
	≥ 30 vs. < 10 years	1.32 (0.87,2.00)	1.49 (0.91,2.45)	1.36* (0.99,1.85)	
	Oncologist medical school:				
	Unknown vs. US	0.84 (0.36,1.92)	0.85 (0.36,2.03)	0.48 (0.13,1.80)	
	Foreign vs. US	0.91 (0.77,1.07)	0.91 (0.76,1.10)	1.14* (1.00,1.30)	

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Physician[b]	Oncologist practice:				
	Small vs. group practice	0.98 (0.81,1.19)	0.89 (0.71,1.12)	0.93 (0.78,1.10)	
	Hospital based vs. group practice	1.18 (0.84,1.67)	0.95 (0.64,1.40)	0.73** (0.56,0.94)	
	Medical school vs. group practice	1.28 (0.71,2.33)	1.23 (0.59,2.53)	1.14 (0.85,1.54)	
	Other vs. group practice	1.04 (0.83,1.30)	1.00 (0.78,1.29)	1.03 (0.87,1.22)	
Hospital[c]	Total number of patients (N)	3,491	2,318	5,993	1,270
	Not a NCI designated cancer facility	1.13** (1.00,1.26)	1.04 (0.89,1.22)	1.05 (0.90,1.23)	1.01 (0.79,1.28)
	Not COTH	0.89* (0.76,1.04)	0.93 (0.79,1.10)	0.84* (0.70,1.01)	0.85 (0.67,1.09)
	Number of hospital beds:				
	101 – 149 vs. < 100 beds	1.15 (0.93,1.42)	1.19 (0.93,1.53)	0.89 (0.70,1.12)	0.87 (0.52,1.47)
	150 – 249 vs. < 100 beds	1.11 (0.89,1.38)	1.14 (0.91,1.43)	0.95 (0.78,1.17)	0.96 (0.57,1.61)
	> 250 vs. < 100 beds	0.95 (0.76,1.19)	0.95 (0.74,1.22)	0.88 (0.69,1.12)	0.89 (0.52,1.50)
	For profit vs. nonprofit hospital	1.75** (1.16,2.64)	1.97* (0.91,4.28)	1.22 (0.86,1.72)	2.28** (1.16,4.48)
	No surgical cancer program	1.01 (0.87,1.18)	1.02 (0.83,1.26)	1.03 (0.88,1.20)	0.99 (0.79,1.25)
	No chemotherapy services	0.93 (0.78,1.10)	0.98 (0.81,1.19)	0.88 (0.73,1.06)	0.76* (0.56,1.03)
	No hospice or palliative care services	1.05 (0.91,1.20)	1.00 (0.85,1.18)	0.99 (0.85,1.14)	0.80* (0.63,1.02)

Table 7c. Association of physician and hospital characteristics on the occurrence of chemotherapy toxicity

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Patient[a]	Total number of patients (N)	1,182	821	4,212	
	Visit with Surgeon	1.50*** (1.12,2.01)	1.55** (1.11,2.16)	1.38*** (1.16,1.64)	
	Visit with Medical Oncologist	1.58** (1.05,2.36)	1.66** (1.00,2.75)	1.02 (0.86,1.22)	
	Visit with Radiation Oncologist	1.01 (0.79,1.30)	0.97 (0.72,1.31)	0.90 (0.79,1.03)	
	Visit with Primary Care Physician	3.03 (0.63,14.49)	2.48 (0.50, 12.25)	2.36** (1.13,4.91)	
Physician[b]	Total number of patients (N)	1,048	743	3,265	
	Oncologist gender (male)	1.44* (0.94,2.21)	1.56** (1.02,2.38)	1.01 (0.82,1.23)	
	Oncologist years since medical school:				
	10 - 19 vs. < 10 years	0.79 (0.43,1.46)	1.12 (0.58,2.17)	1.34 (0.91,1.98)	
	20 - 29 vs. < 10 years	0.73 (0.39,1.36)	0.92 (0.47,1.81)	1.20 (0.82,1.75)	
	> 30 vs. < 10 years	0.70 (0.37,1.35)	1.10 (0.53,2.29)	1.16 (0.78,1.73)	
	Oncologist medical school:				
	Unknown vs. US	1.00 (1.00,1.00)	1.00 (1.00,1.00)	1.20 (0.30,4.85)	
	Foreign vs. US	1.01 (0.74,1.38)	0.85 (0.60,1.19)	0.95 (0.82,1.10)	

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Physician[b]	Oncologist practice:				
	Small vs. group practice	1.32 (0.91,1.90)	1.44* (0.93,2.22)	1.18* (0.98,1.43)	
	Hospital based vs. group practice	0.88 (0.49,1.57)	1.16 (0.54,2.49)	1.02 (0.78,1.32)	
	Medical school vs. group practice	2.92** (1.34,6.38)	2.24** (1.10,4.57)	1.23 (0.79,1.90)	
	Other vs. group practice	0.99 (0.69,1.42)	1.00 (0.65,1.52)	1.03 (0.86,1.24)	
Hospital[c]	Total number of patients (N)	1,402	971	3,405	858
	Not an NCI designated cancer facility	1.01 (0.83,1.24)	1.11 (0.85,1.43)	0.95 (0.80,1.13)	0.97 (0.73,1.29)
	Not COTH	1.23** (0.96,1.57)	1.10 (0.77,1.58)	1.01 (0.82,1.26)	1.31 (0.87,1.97)
	Number of hospital beds:				
	101 – 149 vs. < 100 beds	1.12 (0.81,1.55)	1.08 (0.72,1.62)	0.98 (0.76,1.26)	0.86 (0.54,1.37)
	150 – 249 vs. <100 beds	1.27 (0.93,1.73)	1.24 (0.83,1.85)	1.07 (0.84,1.35)	0.55** (0.35,0.86)
	≥250 vs. <100 beds	0.93 (0.68,1.27)	0.82 (0.55,1.21)	0.86 (0.68,1.10)	0.64* (0.40,1.02)
	For profit vs. nonprofit hospital	2.39 (0.44,12.97)	1.29 (0.19,8.92)	1.22 (0.86,1.73)	0.78 (0.39,1.58)
	No surgical cancer program	0.97 (0.77,1.23)	0.85 (0.62,1.16)	1.05 (0.87,1.26)	0.85 (0.65,1.12)
	No chemotherapy services	0.98 (0.77,1.25)	1.18 (0.86,1.62)	1.21* (0.97,1.51)	1.59** (1.05,2.41)
	No hospice or palliative care services	1.11 (0.91,1.36)	1.05 (0.80,1.37)	0.96 (0.82,1.13)	0.81 (0.62,1.06)

Table 7d. Association of physician and hospital characteristics on lack of admission to hospice

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Patient[a]	Total number of patients (N)	3,541	2,460	11,639	
	Visit with Surgeon	1.40*** (1.20,1.64)	1.31*** (1.09,1.57)	1.34*** (1.22,1.47)	
	Visit with Medical Oncologist	0.87 (0.74,1.02)	0.81** (0.67.0.98)	0.61*** (0.55,0.66)	
	Visit with Radiation Oncologist	0.94 (0.80,1.11)	0.98 (0.82,1.19)	0.69*** (0.63,0.77)	
	Visit with Primary Care Physician	1.12 (0.69,1.80)	1.15 (0.65,2.05)	1.49** (1.11,1.99)	
Physician[b]	Total number of patients (N)	2,021	1,444	5,315	
	Oncologist gender (male)	0.91 (0.68,1.20)	0.99 (0.71,1.40)	0.93 (0.72,1.20)	
	Oncologist years since medical school: 10 - 19 vs. < 10 years 20 - 29 vs. < 10 years > 30 vs. < 10 years	 0.72 (0.39,1.33) 0.75 (0.41,1.41) 1.10 (0.57,2.12)	 0.58 (0.28,1.21) 0.59 (0.28,1.25) 0.95 (0.43,2.07)	 0.94 (0.62,1.43) 0.86 (0.58,1.30) 0.91 (0.60,1.38)	
	Oncologist medical school: Unknown vs. US Foreign vs. US	 1.06 (0.23,4.96) 1.17 (0.93,1.47)	 1.03 (0.22,4.85) 1.09 (0.85,1.40)	 1.18 (0.47,2.96) 1.11 (0.95,1.30)	

Model	Covariate	OR (CL)			
		Prospective cohort		Retrospective cohort	
		P(Death) ≥40%	P(Death)≥60%	Full cohort	NJ Cancer Deaths
Physician[b]	Oncologist practice:				
	Small vs. group practice	1.34** (1.00,1.79)	1.33* (0.97,1.84)	1.22** (1.00,1.48)	
	Hospital based vs. group practice	0.99 (0.60,1.63)	1.11 (0.67,1.84)	1.03 (0.80,1.34)	
	Medical school vs. group practice	1.01 (0.61,1.65)	1.19 (0.71,1.99)	1.46** (1.04,2.05)	
	Other vs. group practice	1.18 (0.85,1.64)	1.19 (0.82,1.73)	1.01 (0.80,1.27)	
Hospital[c]	Total number of patients (N)	2,762	1,845	6,607	1,467
	Not a NCI designated cancer facility	1.11 (0.95,1.31)	1.11 (0.93,1.34)	1.07 (0.93,1.23)	0.97 (0.78,1.20)
	Not COTH	0.96 (0.77,1.19)	1.21 (0.92,1.58)	1.25** (1.03,1.52)	1.54*** (1.21,1.97)
	Number of hospital beds:				
	101 – 149 vs. < 100 beds	0.94 (0.71,1.24)	0.91 (0.65,1.27)	0.90 (0.74,1.09)	0.47*** (0.32,0.69)
	150 – 249 vs. < 100 beds	0.94 (0.69,1.29)	0.87 (0.60,1.26)	0.84 (0.68,1.04)	0.43*** (0.31,0.61)
	> 250 vs. < 100 beds	0.93 (0.68,1.27)	0.89 (0.62,1.29)	0.92 (0.73,1.16)	0.47*** (0.32,0.70)
	For profit vs. nonprofit hospital	1.28 (0.65,2.53)	1.17 (0.49,2.81)	1.29 (0.77,2.16)	0.20*** (0.13,0.33)
	No surgical cancer program	0.90 (0.73,1.11)	0.77** (0.60,0.97)	0.86* (0.73,1.01)	0.86 (0.69,1.07)
	No chemotherapy services	1.26 (0.94,1.69)	1.38* (0.98,1.93)	1.14 (0.91,1.42)	1.45** (1.02,2.04)
	No hospice or palliative care services	0.91 (0.74,1.10)	0.89 (0.71,1.12)	0.94 (0.81,1.10)	0.84 (0.66,1.07)

Physician and hospital models were analyzed by generalized estimating equations to account for patients being clustered within physicians or hospitals depending on the model. Observations in the patient model were assumed independent.

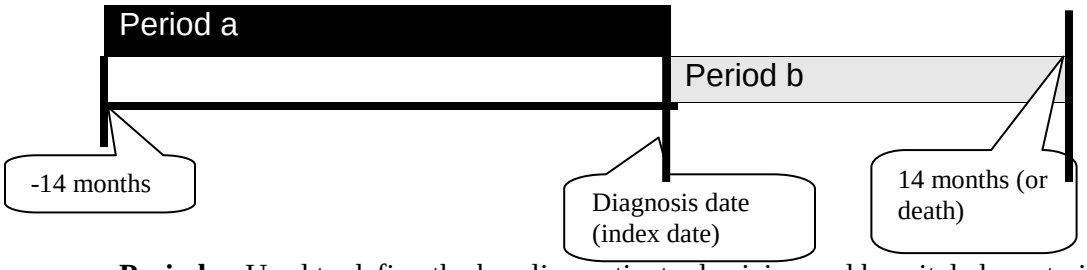
[a]Variables included in Patient Model were: age, gender, race, income, primary site of cancer, Charlson score, cancer stage, year of diagnosis, visit with surgeon, visit with medical oncologist, visit with radiation oncologist, and visit with PCP.

[b]Variables included in Physician Model were: age, gender, race, income, primary site of cancer, Charlson score, cancer stage, year of diagnosis, gender of oncologist, years since medical school, international medical graduate, small practice, hospital based practice, and practice at medical school.

[c]Variables included in Hospital Model were: age, gender, race, income, primary site of cancer, Charlson score, cancer stage, year of diagnosis, non-NCI facility, non-teaching hospital, number of hospital beds, for profit hospital, chemotherapy services, and hospice or palliative care.

Asterisks denote the significance of the Z scores for rejecting a null finding (OR=1). "" = less than 0.1, "**"=less than 0.05, "***"=less then 0.005

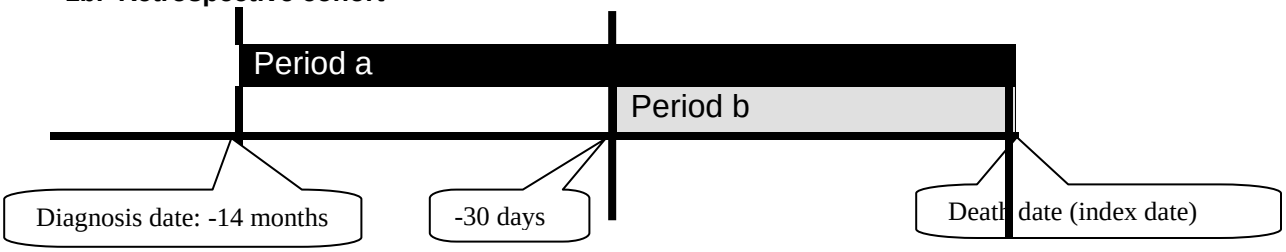
Figure 1. Time period under observation, prospective and retrospective cohorts
1a. Prospective cohort



Period a: Used to define the baseline patient, physician and hospital characteristics.

Period b: Used to define the benchmarks (except for chemotherapy toxicity and use of hospice within 3 days of death). These benchmarks were measured for any time up to 14 months or date of death if death occurred within the 14-month period. Chemotherapy toxicity was calculated for events that occurred between the receipt of the first chemotherapy regimen and the last chemotherapy regimen plus 90 days. Therefore, the denominator for this benchmark measure included only those patients who had chemotherapy within 14 months after diagnosis.

1b. Retrospective cohort



Period a: Used to define the baseline patient, physician and hospital characteristics. The benchmark measure for chemotherapy toxicity is also measured for this time period.

Period b: Used to define receipt of chemotherapy, a new chemotherapy regimen, $\geq$ 1 ED visit, $\geq$ 1 hospital admission, admission to the ICU, and prescription of opiates.

Appendixes

Appendix A: Codes To Identify Chemotherapy Drugs

Chemotherapy Regimen	HCPC	Description
Doxorubin HCl	J9000	Doxorubicin HCl, 10 mg
	J9001	Doxorubicin HCl, all lipid formulations, 10 mg
Aldesleukin	J9015	Aldesleukin, per single use vial
Asparaginases	J9020	Asparaginase, 10,000 units
BCG live (intravesical)	J9031	BCG live (intravesical), per instillation
Bleomycin sulfate	J9040	Bleomycin sulfate, 15 units
Bulsulfan oral	J8510	Bulsulfan; oral, 2 mg
Capecitabine oral	J8520	Capecitabine, oral, 150 mg
	J8521	Capecitabine, oral, 500 mg
Carboplatin	J9045	Carboplatin, 50 mg
Carmustine	J9050	Carmustine, 100 mg
Cisplatin	J9060	Cisplatin, powder or solution, per 10 mg
	J9062	Cisplatin, 50 mg
Cladribine injection	J9065	Injection, cladribine, per 1 mg
Cyclophosphamide	J8530	Cyclophosphamide, oral, 25 mg
	J9070	Cyclophosphamide, 100 mg
	J9080	Cyclophosphamide, 200 mg
	J9090	Cyclophosphamide, 500 mg
	J9091	Cyclophosphamide, 1 g
	J9092	Cyclophosphamide, 2 g
	J9093	Cyclophosphamide, lyophilized, 100 mg
	J9094	Cyclophosphamide, lyophilized, 200 mg
	J9095	Cyclophosphamide, lyophilized, 500 mg
	J9096	Cyclophosphamide, lyophilized, 1 g
	J9097	Cyclophosphamide, lyophilized, 2 g
Cytaribine	J9100	Cytarabine, 100 mg
	J9110	Cytarabine, 500 mg
Dactinomycin	J9120	Dactinomycin, 0.5 mg
Dacarbazine	J9130	Dacarbazine, 100 mg
	J9140	Dacarbazine, 200 mg
Daunorubicin	J9150	Daunorubicin HCl, 10 mg
	J9151	Daunorubicin citrate, liposomal formulation, 10 mg
Denileukin diftitox	J9160	Denileukin diftitox, 300 mcg
Diethylstilbstrol diphosphate	J9165	Diethylstilbestrol diphosphate, 250 mg
Docetaxel	J9170	Docetaxel, 20 mg
Epirubicin HCl	J9180	
Etoposide	J8560	Etoposide, oral, 50 mg
	J9181	Etoposide, 10 mg
	J9182	Etoposide, 100 mg
Fludarabine phosphate	J9185	Fludarabine phosphate, 50 mg
Fluorouracil	J9190	Fluorouracil, 500 mg
Floxuridine	J9200	Floxuridine, 500 mg
Gemcitabine HCl	J9201	Gemcitabine HCl, 200 mg
Goserelin acetate implant	J9202	Goserelin acetate implant, per 3.6 mg
Irinotecan	J9206	Irinotecan, 20 mg
Ifosfamide	J9208	Ifosfamide, per 1 g
Idarubicin HCl	J9209	Mesna, 200 mg
Interferon	J9211	Idarubicin HCl, 5 mg

Leuprolide acetate	J9212 J9213 J9214 J9215 J9216	Injection, interferon alfacon-1, recombinant, 1 mcg Interferon alfa-2A, recombinant, 3 million units Interferon alfa-2B, recombinant, 1 million units Interferon alfa-N3, (human leukocyte derived), 250,000 IU Interferon gamma-1B, 3 million units
Mechlorethamine HCl	J9217 J9218 J9219	Leuprolide acetate (for depot suspension), 7.5 mg Leuprolide acetate, per 1 mg Leuprolide acetate implant, 65 mg
Melphalan HCl injection/oral	J9230	Mechlorethamine HCl, (nitrogen mustard), 10 mg
Mesna	J8600 J9245	Melphalan, oral 2 mg Injection, melphalan HCl, 50 mg
Methotrexate sodium/oral	J8610 J9250 J9260	Methotrexate, oral, 2.5 mg Methotrexate sodium, 5 mg Methotrexate sodium, 50 mg
Mitomycin	J9265	Paclitaxel, 30 mg
Mitoxantron HCl, injection	J9266	Pegaspargase, per single dose vial
Paclitaxel	J9268	Pentostatin, per 10 mg
Pegaspargase	J9270	Plicamycin, 2.5 mg
Pentostatin	J9280 J9290 J9291	Mitomycin, 5 mg Mitomycin, 20 mg Mitomycin, 40 mg
Plicamycin	J9293	Injection, mitoxantrone HCl, per 5 mg
Pituximab	J9310	Rituximab, 100 mg
Streptozocin	J9320	Streptozocin, 1 g
Temozolomide oral	J8700	Temozolomide, oral, 5 mg
Thiotepa	J9340	Thiotepa, 15 mg
Topotecan	J9350	Topotecan, 4 mg
Trastuzamab	J9355	Trastuzumab, 10 mg
Valrubicin, intravesical	J9357	Valrubicin, intravesical, 200 mg
Vinblastine sulfate	J9360	Vinblastine sulfate, 1 mg
Vincristine sulfate	J9370 J9375 J9380	Vincristine sulfate, 1 mg Vincristine sulfate, 2 mg Vincristine sulfate, 5 mg
Vinorelbine tartrate	J9390	Vinorelbine tartrate, per 10 mg
Porfimer sodium	J9600	Porfimer sodium, 75 mg
Antineoplastic drug, not otherwise classified	J9999	NOC, antineoplastic drug
Oral chemotherapeutic NOS	J8999	Prescription drug, oral, chemotherapeutic, NOS
Cetuximab injection 10 mg (Erbitux)	J9055	Injection, cetuximab, 10 mg
Capecitabine 150 mg Oral (Xeloda)	J8250	
Capecitabine 500 mg Oral (Xeloda)	J8251	
Abarelix 10 mg injection (Plenaxis)	J0128	Injection, abarelix, 10 mg
Bavacizumab 10 mg Injection (Avastin)	J9035	Injection, bevacizumab, 10 mg
Docetaxol 20 mg Injection (Taxotere)	J9170	Docetaxel, 20 mg
Oxaliplatin 0.5 mg Injection (Eloxatin)	J9263	Injection, oxaliplatin, 0.5 mg
Pegfilgrastin 6 mg Injection (Neulasta)	J2505	Injection, pegfilgrastim, 6 mg
Gefitinib 250 mg Tablet (Iressa)	J8565	Gefitinib, oral, 250 mg

Appendix B: List of Opiates

Opiate	**Active Opiate Ingredient**	**Generic Name ***
Short Acting		
	Codeine **	Codeine phosphate
		Codeine sulfate
		Acetaminophen w/codeine
		Aspirin w/ codeine
		Codeine phosphate/ apap
		Codeine/calcium iodide
		Codeine phos/carisoprodol/aspirin
		Codeine/apap/caffein/butalb
		Codeine/iodinated glycerol
		Codeine/sal-amide/apap/phenac
		Codeine sulfate/pot citrate
	Fentanyl	Fentanyl citrate (short-acting)
	Hydrocodone	Hydrocodone bitartrate /acetaminophen
		Hydrocodone bitartrate
		Hydrocodone bitartrate /aspirin
		Hydrocodone bitartrate /ibuprofen
	Hydromorphone	Hydromorphone hydrochloride (short-acting)
	Merperideine	Meperidine hydrochloride
		Meperidine hydrochloride /atropine sulfate
		Meperidine/asa/phenacet/caff
		Meperidine hcl/promethazine hcl
		Meperidine hcl/acetaminophen
	Morphine	Morphine sulfate (short acting)
		Morphine sulfate/atrop sulf
	Oxycodone	Ibuprofen/oxycodone hcl
		Oxycodone hcl
		Oxycodone hcl/acetaminophen
		Oxycodone/aspirin
	Pentazocine	Pentazocine hydrochloride
		Pentazocine lactate
		Pentazocine/ naloxone hcl
		Pentazocine hcl/acetaminophen
	Propoxyphene	Propoxyphene hcl
		Propoxyphene napsylate
		Propoxyphene napsyl/acetaminophen
		Propoxyphene hcl/aspirin
	Tramadol	Tramadol hcl/acetaminophen
		Tramadol hcl/acetaminophen

Opiate	**Active Opiate Ingredient**	**Generic Name ***
Long Acting		
	Fentanyl	Fentanyl patch
	Hydromorphone	Hydromorphone hydrochloride (long-acting)
	Levorphanol	Levorphanol tartrate
	Methadone	Methadone hydrochloride
	Morphine	Morphine sulfate (long acting)
	Oxycodone	Oxycodone (long acting)
	Tramadol	Tramadol hcl (Long-acting)

*Includes all strengths and formulations.
**Codeine preparations in combination with decongestants or expectorants were excluded.

Appendix C: List of Chemotherapy Toxicity Codes

Toxicity	Code
Electrolytes	ICD-9: 276.1, 276.8, 276.9, 99.2, 276.5
Constitution	ICD-9: 780.8, 780.2, 780.4, E9331, 787.9 DRG: 65, 141-142, 452-453, 463-464
Nausea	ICD-9: 787.9, 564.5, 787.0
Infection	ICD-9: 490, 480-486, 487, 590, 595.0, 681-682, 510, 513, V58.62, 38.9, 790.7, 785.50, 785.52, 785.59, 780.6, 99.21, 99.22, 907.88 DRG: 079-080, 089-090, 277-278, 320-321, 416, 419-420, 423
Malnutrition	ICD-9: 783.21, 783.7, 799.4, 783.0, 783.22, 263.9, 99.15 DRG: 296-297
Anemia	ICD-9: 280, 281, 284, 285, V58.2, 99.03, 99.04, 364.30 DRG: 395
Neutropenia	ICD-9: 288.0, 288.8, 288.9, 287.4, 99.05
DVT	ICD-9: 451, 415.19 DRG: 78
FX	ICD-9: 800-829, 830-839 DRG: 235, 236
Asthma	ICD-9: 491, 492, 493 DRG: 88
Renal	ICD-9: 584, 585, 586 DRG: 316
Thyroid	ICD-9: 240, 241, 242, 243, 244, 245
Headache	ICD-9: 784.0, 346