Duke Clinical Research Institute
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REPORT:

Chemotherapy After the Medicare Modernization Act: Have Changes in Reimbursement Policy Affected Access to Care?

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Table of Contents

Executive Summary

As a result of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (MMA), reimbursement for outpatient chemotherapy drugs and drug administration services has undergone a significant change. Many fear that these adjustments will affect reimbursement such that payment rates will be insufficient to cover the costs of providing chemotherapy to Medicare beneficiaries. However, while a significant amount of anecdotal evidence exists to support this prediction, there is currently no published empirical data showing the same.

The objective of this analysis was to determine whether Medicare beneficiary access to care has been affected by changes in chemotherapy reimbursement methodology as mandated by the Medicare Modernization Act. We used a nationally representative 5% sample of Medicare beneficiaries from 2002 through 2005 to identify patients with incident breast, colorectal or lung cancer, leukemia, or lymphoma who received chemotherapy treatment in inpatient hospital, institutional outpatient, or physician office settings. We measured wait time for treatment as days from incident diagnosis to the date of the first observed chemotherapy claim. We also calculated the distance traveled for treatment in miles. Because the initial, transitional MMA-mandated changes in Medicare payment for cancer drugs and administration began in 2004, with more significant changes implemented in 2005, 2004 was employed as the referent year.

After controlling for the effect of age, sex, race, cancer type, region, comorbid diagnoses and year, differences in average wait time for chemotherapy treatment in 2003 and 2005 relative to 2004 were not significant. Patients traveled 1.6 fewer miles for chemotherapy in 2003 than in 2004, but distances were unchanged in 2005. Our results do not support anecdotal reports that the MMA has had a significant negative impact on patient access to care through 2005.

Introduction

With the passage of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (MMA), many expressed concern that the proposed changes in Medicare reimbursement for outpatient chemotherapy drugs would negatively affect patient access to care. Prior to the MMA, oncologists were reimbursed for chemotherapy related drugs at a rate of 95% of the average wholesale price. However, because a large number of physicians were able to obtain these drugs at substantially discounted prices, Medicare reimbursement was often much higher than actual costs.[1] In an effort to curtail this overpayment and align reimbursement more closely with actual market prices, the MMA reduced payment for cancer drugs in 2004 from 95% of average wholesale price to 85% of average wholesale price. In 2005, payment was further reduced to 106% of average *sales* price, which reflects the actual transaction prices of drug acquisition and is typically lower than the corresponding wholesale values.[2] To offset these reductions somewhat, however, the MMA also increased reimbursement for drug administration services.[3]

Concerns have been raised that this decrease in reimbursement for chemotherapy drugs could result in the closure of many private oncology practices. In turn, these closures could force the 80% of cancer patients currently treated in community settings to travel further from their homes to local hospitals in order to receive treatment.[4,5,6,7,8] Even more, without sufficient

[1] General Accounting Office. Medicare: payments for covered outpatient drugs exceed providers' cost. 2001 Sep. Report No.: GAO-01-1118.
[2] Medicare Payment Advisory Commission. Report to the Congress: Effects of Medicare payment changes on oncology services. *Medicare Payment Advisory Commission.* 2006 Jan.
[3] U.S.Government Accountability Office. Medicare Chemotherapy Payments: New Drug and Administration Fees Are Closer to Providers' Costs. 2004 Dec 1. Report No: GAO-05-142R.
[4] Bush Proposes Cuts in Medicare Payments. Los Angeles Times 2004 Jul 28; A19.
[5] Heumann J. Medicare bill threatens oncology practices and patient access to care. American Society of Clinical Oncology 2003 Nov 25.
[6] Huff C. Chemo & Medicare. Could a new payment plan force more cancer patients to your doorsteps? *Hosp Health Netw* 2004 November;78(11):62-66.
[7] Stein R. Medicare Law Hurts Cancer Patients; Some Find it Harder to Get Chemotherapy. The Washington Post 2004 Feb 14;A01.

opportunity to plan and expand their services, these hospital-based clinics may not have adequate resources available to support the rapid influx of patients seeking chemotherapy, thereby further delaying the provision of care.[9] Where private clinics are able to remain viable, opponents warn that quality of care may suffer, as financial constraints will necessitate the elimination of nursing and other support staff [10] and cost shifting to patients in the form of large out-of-pocket drug copayments may force some to forego care altogether.[11]

Despite these concerns, a recent focus group study conducted by the Medicare Payment Advisory Commission found that cancer patients were generally satisfied with their care and did not perceive changes in treatment following the MMA legislation. [12,13,14] Still, limited systematic evidence exists as to whether changes in reimbursement policy are in fact affecting the location or timeliness of chemotherapy.[15]

Using a nationally representative sample of Medicare beneficiaries from 2002 through 2005, we sought to examine changes in access to care pre-MMA and post-MMA, as measured by time from incident diagnosis to initial chemotherapy treatment, treatment location, and distance traveled for treatment—all variables which are readily observable in claims data.

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[8] Harris G. New Payment System Spurs Talk of Return to Hospital Care and Old Drugs. The New York Times 2004 Mar 11;C1.
[9] Huff C. Chemo & Medicare. Could a new payment plan force more cancer patients to your doorsteps? *Hosp Health Netw* 2004 November;78(11):62-66.
[10] Stein R. Medicare Law Hurts Cancer Patients; Some Find it Harder to Get Chemotherapy. The Washington Post 2004 Feb 14;A01.
[11] Berenson A. Incentives Limit Any Savings in Treating Cancer. The New York Times 2007 Jun 12.
[12] Medicare Payment Advisory Commission. Report to the Congress: Effects of Medicare payment changes on oncology services. *Medicare Payment Advisory Commission.* 2006 Jan.
[13] Berenson A. Incentives Limit Any Savings in Treating Cancer. The New York Times 2007 Jun 12.
[14] Friedman JY, Curtis LH, Hammill BG, Dhillon JK, Weaver CH, Biswas S, Abernethy AP., Schulman KA. The Medicare Modernization Act and Reimbursement for Outpatient Chemotherapy: Do Patients Perceive Changes in Access to Care? *Cancer* 2007. In press.
[15] Friedman JY, Curtis LH, Hammill BG, Dhillon JK, Weaver CH, Biswas S, Abernethy AP., Schulman KA. The Medicare Modernization Act and Reimbursement for Outpatient Chemotherapy: Do Patients Perceive Changes in Access to Care? *Cancer* 2007. In press.

Subjects and Methods

We used the Medicare inpatient, outpatient, carrier and durable medical equipment (DME) standard analytic files (a 5% national sample) and the corresponding denominator files. The inpatient files contain institutional claims submitted for facility costs covered under Medicare Part A, and the outpatient files contain claims submitted by institutional outpatient providers (eg, hospital outpatient departments, ambulatory surgery centers). The carrier files contain provider claims for services covered under Medicare Part B. The denominator file contains beneficiary identifiers, dates of birth, sex, race/ethnicity, dates of death, beneficiary contact ZIP Code and information about program eligibility and enrollment.

We obtained all files for the period from 2002 through 2005 from the Centers for Medicare and Medicaid Services (CMS). We eliminated invalid records and limited the analysis to persons living in the United States.

For carrier claims, we utilized the provider ZIP Code present in the CMS files to determine the location of treatment. For inpatient and outpatient institutional claims, we linked Medicare Provider IDs to Medicare Cost Report data in order to obtain facility ZIP Codes.

Patients

We included beneficiaries for whom a diagnosis of leukemia, lymphoma, lung, breast, or colorectal cancer was reported on a single inpatient, outpatient, carrier, or DME claim (see Appendix A for cancer definitions). To specify the date of disease onset ("incident diagnosis"), we used the date of the earliest observed cancer claim. In order to be considered an incident case, we required beneficiaries to have had no claims for a given cancer type in the previous calendar year. We limited the sample to beneficiaries aged 67 years and older in order minimize the risk of misclassifying a prevalent case as incident. In the event that a beneficiary was

identified as an incident case of more than one of the five cancer types within a given year, the cancer with the earliest incident date was retained for analysis.

Inclusion in the incident cohort was conditional on survival to chemotherapy and the initial chemotherapy visit was required to be in the same calendar year as the incident diagnosis. (see Appendix B for chemotherapy definitions). To identify the date of the first chemotherapy visit, we used the date of the earliest observed chemotherapy claim following an incident cancer diagnosis. Carrier and DME chemotherapy claims provided in locations other than inpatient facility, outpatient facility, or physician office were excluded (n=293). Beneficiaries traveling more than 100 miles for treatment were considered outliers and also excluded from the analysis (n=873).

Statistical Analysis

We examined characteristics of patients in the incident cohort. Categorical variables are presented as frequencies, and continuous variables are presented as means with standard deviations (SDs). We identified comorbid conditions using the coding algorithms described by Birman-Deych et al [16] and Quan et al.[17] Specifically, we searched all inpatient, outpatient, and carrier claims for 365 days preceding the date of incident diagnosis for evidence of coronary heart disease (ICD-9-CM codes 410.x-414.x, 429.2, V45.81), hypertension (ICD-9-CM codes 401.x-405.x, 437.2), cerebrovascular disease (ICD-9-CM codes 362.34, 430.x-438.x), dementia (ICD-9-CM codes 290.x, 294.1, 331.2), chronic obstructive pulmonary disease (ICD-9-CM codes 416.8, 416.9, 490.x-505.x, 506.4, 508.1, 508.8), diabetes mellitus (ICD-9-CM code 250.x), peripheral vascular disease (ICD-9-CM codes 093.0 437.3, 440.x, 441.x, 443.1-443.9, 47.1,

[16] Birman-Deych E, Waterman AD, Yan Y, Nilasena DS, Radford MJ, Gage BF. Accuracy of ICD-9-CM codes for identifying cardiovascular and stroke risk factors. *Med Care* 2005 May;43(5):480-5.
[17] Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005 November;43(11):1130-9.

557.1, 557.9, V43.4), kidney disease (ICD-9-CM codes 403.01, 403.11, 403.91, 404.02, 404.036, 404.12, 404.13, 404.92, 404.93, 582.x, 583.0-583.7, 585.x, 586.x, 588.0, V42.0, V45.1, V56.x), or cancer (ICD-9-CM codes 196.x-199.x). To test the statistical significance of changes from 2003 to 2004 and 2004 to 2005, we used chi-square tests for categorical variables and Wilcoxon rank sum tests for continuous variables.

Because the initial, transitional MMA-mandated changes in Medicare payment for cancer drugs and administration began in 2004, with more significant changes implemented in 2005, we chose to use 2004 as our referent year. We measured days from incident diagnosis to the date of the first chemotherapy treatment. We also calculated the distance traveled for treatment using the beneficiary's contact ZIP Code as provided by CMS and the ZIP of the provider administering the chemotherapy as described above. Distances were measured in miles and calculated based on straight lines from beneficiary ZIP Code centroid to provider ZIP Code centroid. ZIP centroids were obtained using a built-in SAS-written function.[18] To examine the unadjusted relationship between study variables and the number of days from diagnosis to treatment, we employed a survival framework using a Cox proportional hazards regression model. The hazard ratios estimate the effect of a given covariate on days to treatment. Consequently, hazard ratios in excess of 1.0 suggest shorter wait times as compared to the referent group while hazard ratios less than 1.0 imply longer wait times. To examine the unadjusted relationship between study variables and the mean distance traveled for treatment, we used a linear regression model. We also fit multivariable models for each measurement described above using age, sex, race, cancer type, region, comorbid diagnoses and year in order to control for these factors. That is, controlling for the other variables in the model, we

[18] SASHELP.ZIPCODE file. SAS Institute, Inc. Available at: http://support.sas.com/rnd/datavisualization/mapsonline/html/misc.html. Accessed June 6, 2007.

determined whether distance traveled for chemotherapy or days elapsed between diagnosis and treatment were significantly different in 2005 or 2003 relative to 2004.

We used SAS version 9.1.5 for all analyses (SAS Institute Inc, Cary, NC). This study was approved by the institutional review board of the Duke University Health System.

Results

In this nationally representative 5% sample of Medicare beneficiaries, there were 4,975 incident cases of leukemia, lymphoma, breast, colorectal or lung cancer in 2003; 5,153 incident cases in 2004; and 4,869 cases in 2005. As shown in Table 1, sample demographic characteristics were consistent across years. Patient comorbities were also quite stable, with the exception of cerebrovascular disease, diabetes, and kidney disease, which were observed significantly more often in 2004 than in 2003. Hypertension was also observed significantly more frequently in each study year. Half of all incident cancer patients were male, and nearly 90% were white. Mean age remained constant at 75 years.

In each year, approximately 70% of the sample received their first chemotherapy treatment in a physician office, and just fewer than 7% received treatment in an inpatient hospital setting. The remainder were treated in institutional outpatient facilities. Although differences in treatment location (inpatient, outpatient or physician office) between 2003 and 2004 were not statistically significant, a small but significant shift was observed from 2004 to 2005. In other words, while the proportion of patients receiving chemotherapy in inpatient settings remained about the same, physician office treatment decreased from 2004 to 2005 (72.8% to 70.2%), and institutional outpatient treatment increased during this time (20.3% to 23.2%). (Table 1) Due to our relatively large sample size, this change is statistically significant; however, in absolute numbers, it affected less than 3% of sample beneficiaries.

Median distance traveled for chemotherapy treatment from 2003 to 2004 increased significantly across all treatment settings; however changes in distance traveled from 2004 to 2005 were not significant. In fact, median distance traveled for treatment in an inpatient setting decreased by 2 miles from 2004 to 2005. For chemotherapy received in inpatient and outpatient facilities, annual changes in median wait time from 2003 to 2005 were not significant. Median

wait time for treatment in a physician office increased significantly from 2003 to 2004 (p=0.05) and 2004 to 2005 (p=0.01). (Table 2)

The unadjusted relationship between study variables and days to initial chemotherapy treatment is displayed in Table 3. As shown, men received chemotherapy slightly more quickly than women (Hazard Ratio (HR) 1.08; 95% Confidence Interval (CI) 1.05-1.12). The mean number of days from incident diagnosis to initiation of chemotherapy was greater for patients diagnosed with breast cancer, colorectal cancer, and leukemia than for those diagnosed with lymphoma. Patients with a history of COPD received chemotherapy 10% faster than those without (HR 1.10; CI 1.07-1.14), while patients with a history of cancer (other than those studied here) received chemotherapy 60% faster (HR 1.60; CI 1.54-1.65). Patients with a history of hypertension received chemotherapy slightly less quickly (HR 0.95; CI 0.92-0.99), as did patients living in the northeastern region of the U.S. compared to those living in the west (HR 0.93; CI 0.88-0.98).

With regard to the distance traveled for treatment, white beneficiaries traveled farther than beneficiaries of other races (Parameter Estimate (PE) 3.73; CI 2.66-4.80), while older patients traveled less far (PE -0.2; CI -0.24- -0.15). Patients with leukemia traveled significantly farther than those with other cancer types. Relative to beneficiaries in the western U.S. census region, patients in the northeast traveled significantly fewer miles, while patients in the south and midwest traveled more. (Table 4)

The number of days from incident diagnosis to receipt of chemotherapy was not significantly different from 2003 to 2004 or 2004 to 2005. (Table 3) Relative to 2004, mean distance traveled for chemotherapy was significantly less in 2003, but unchanged in 2005. (Table 4)

After controlling for the effect of age, sex, race, cancer type, region, comorbid diagnoses and year, mean days from diagnosis to initiation of chemotherapy was still significantly greater

for patients diagnosed with any of the other cancers as compared to those diagnosed with lymphoma. Whites and patients of other races waited significantly less long for chemotherapy than did black patients. Patients with a previous cancer diagnosis received treatment 59% more quickly than those with no recent history of cancer (HR 1.59; CI 1.53-1.64). Relative to beneficiaries living in the western U.S. census region, beneficiaries in the northeast received chemotherapy 9% less quickly (HR 0.92; CI 0.87-0.97). (Table 3)

Controlling for other factors, whites and patients of other races traveled significantly farther than black patients for their initial chemotherapy visit. Compared to patients in the west, those in the northeast traveled approximately 2 miles less, while patients in the midwest traveled 2.7 miles more and patients in the south traveled almost 4.5 miles more. (Table 4)

Differences in average wait time in 2003 and 2005 relative to 2004 were not significant. (Table 3) Patients traveled 1.6 fewer miles for chemotherapy in 2003 than in 2004, but distances were unchanged in 2005. (Table 4)

Discussion

As a result of the Medicare Modernization Act, reimbursement for chemotherapy-related drugs and drug administration services has undergone a significant change.

Because Medicare had previously reimbursed for chemotherapy-related drugs at a rate much higher than actual costs, these payments were restructured to more accurately reflect real market prices. Although the MMA simultaneously increased reimbursement for drug administration services—for which payment was previously considered inadequate—and provided the opportunity for additional revenue through demonstration project payments, many believed that these adjustments would be insufficient to cover the costs of providing chemotherapy given the new drug payment rates. While a significant amount of anecdotal evidence exists to support this prediction,[19,20,21,22,23,24,25,26,27] there is currently no published empirical data showing the same.

[19] General Accounting Office. Medicare: payments for covered outpatient drugs exceed providers' cost. 2001 Sep. Report No.: GAO-01-1118.
[20] Heumann J. Medicare bill threatens oncology practices and patient access to care. American Society of Clinical Oncology 2003 Nov 25.
[21] Huff C. Chemo & Medicare. Could a new payment plan force more cancer patients to your doorsteps? *Hosp Health Netw* 2004 November;78(11):62-66.
[22] Stein R. Medicare Law Hurts Cancer Patients; Some Find it Harder to Get Chemotherapy. The Washington Post 2004 Feb 14;A01.
[23] Harris G. New Payment System Spurs Talk of Return to Hospital Care and Old Drugs. The New York Times 2004 Mar 11;C1.
[24] Berenson A. Incentives Limit Any Savings in Treating Cancer. The New York Times 2007 Jun 12.
[25] Siegel J. Impact of the Medicare Prescription Drug Improvement and Modernization Act on the management of colorectal cancer. *Am J Health Syst Pharm* 2006 May 1;63(9 Suppl 2):S18-S21.
[26] Twombly R. Medicare cost containment strategy targets several oncology drugs. *J Natl Cancer Inst* 2004 September 1;96(17):1268-70.
[27] Twombly R. New Medicare bill targets discrepancies in fees for cancer drugs, outpatient services. *J Natl Cancer Inst* 2004 February 4;96(3):166-8.

We used the Medicare inpatient, outpatient, carrier, and durable medical equipment 5% standard analytic files in order to identify a sample cohort of Medicare beneficiaries with incident leukemia, lymphoma, breast, colorectal, or lung cancer who received chemotherapy in 2003, 2004 or 2005.

Because transitional payment reductions for chemotherapy drugs under the MMA first began in 2004, with more significant changes implemented the following year, we analyzed time to initiation of chemotherapy and distance traveled for chemotherapy in 2003 and 2005 relative to 2004.

Opponents of the MMA have argued that decreased chemotherapy drug payments would be inadequate to cover costs and would force community-based clinics to either refer patients to area hospitals for treatment or close their practices entirely, requiring patients travel further from their homes for treatment.

Our results did not show a significant change in treatment location from 2003 to 2004, although we did observe a small (<3%) shift in the provision of initial chemotherapy treatment from physician offices to institutional outpatient settings between 2004 and 2005.

Across all treatment locations, patients traveled 1.6 miles less for treatment in 2003 than in 2004, but we observed no change in mean distance traveled between 2004 and 2005 after controlling for age, sex, race, cancer type, region, and comorbid diagnoses.

Consistent with the migration of patients from community-based practices to hospital settings, many have also expressed concern that increased travel requirements and longer wait times at overburdened facilities would serve to delay the initiation of chemotherapy. We did not observe a statistically significant change in wait time for chemotherapy treatment in inpatient or

facility-based outpatient settings from 2003 to 2005. Wait times for physician office treatment, however, increased steadily over this period. (Table 2) But overall—across all treatment settings and after adjustment for other factors—we did not observe a significant change in time to treatment at any point during the study period. (Table 3)

Relative to patients in the west, patients in the northeast traveled shorter distances on average yet waited longer to receive initial treatment. This may simply reflect the density of population in the northeastern United States, where treatment facilities may be closer geographically and also responsible for a much higher volume of patients than in other areas of the country. It is unclear why patients traveled greater distances for treatment in the south, although previous studies have shown that significant differences in cancer treatment[28,29,30] and chemotherapy use[31] exist between geographic regions.

Our analysis has some limitations. First, the coding of diagnoses and procedures in claims data may not always be accurate or complete. However, previous studies have shown that diagnosis information on Medicare claims can be used to identify incident cancer with high specificity[32] and that claims are a valid source of information for the identification of chemotherapy services.[33,34,35] A second limitation is that Medicare data does not include claims

[28] Baxter NN, Virnig BA, Durham SB, Tuttle TM. Trends in the treatment of ductal carcinoma in situ of the breast. *J Natl Cancer Inst* 2004 March 17;96(6):443-8.
[29] Farrow DC, Hunt WC, Samet JM. Geographic variation in the treatment of localized breast cancer. *N Engl J Med* 1992 April 23;326(17):1097-101.
[30] Lu-Yao GL, Greenberg ER. Changes in prostate cancer incidence and treatment in USA. *Lancet* 1994 January 29;343(8892):251-4.
[31] Polsky D, Armstrong KA, Randall TC, Ross RN, Even-Shoshan O, Rosenbaum PR, Silber JH. Variation in chemotherapy utilization in ovarian cancer: the relative contribution of geography. *Health Serv Res* 2006 December;41(6):2201-18.
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[34] Du XL, Key CR, Dickie L, Darling R, Geraci JM, Zhang D. External validation of medicare claims for breast cancer chemotherapy compared with medical chart reviews. *Med Care* 2006 February;44(2):124-31.
[35] Lamont EB, Herndon JE, Weeks JC, Henderson IC, Lilenbaum R, Schilsky RL, Christakis NA. Criterion validity of Medicare chemotherapy claims in Cancer and Leukemia Group B breast and lung cancer trial participants. *J Natl Cancer Inst* 2005 July 20;97(14):1080-3.

for beneficiaries during periods of HMO enrollment. Similarly, ascertainment bias results when a person does not have contact with the medical care system. A cancer diagnosis can only be recorded if there was a visit; therefore, the effect of ascertainment bias is a bias toward accepting the null hypothesis. The effect of reimbursement changes in 2004 may have also been somewhat mitigated by payments made to physicians for the concurrent CMS cancer demonstrations project, and physicians may not have fully responded to the implications of the new reimbursement system by 2005. Finally, our analysis of this administrative dataset did not include any measures of quality or patient satisfaction.

As the population of the United States ages and the number of individuals age 65 and older continues to grow, the number of elderly persons with cancer is expected to increase proportionally, with incidence doubling in less than 30 years.[36]

- ***As measured by distance traveled and time to chemotherapy treatment, our results do not support anecdotal reports that the MMA has already had a significant negative impact on patient access to care.***
- ***Our results show a very gradual trend toward increased wait times and travel required for chemotherapy. Whether this is simply a function of increased demand or if it is the result of recent policy changes is difficult to determine and should be reassessed once more current data are available.***

Given the slow transition to full implementation of the reimbursement changes mandated by the MMA, it may still be too premature to observe the impact of these changes on delivery of care.

[36] Edwards BK, Howe HL, Ries LA, Thun MJ, Rosenberg HM, Yancik R, Wingo PA, Jemal A, Feigal EG. Annual report to the nation on the status of cancer, 1973-1999, featuring implications of age and aging on U.S. cancer burden. *Cancer* 2002 May 15;94(10):2766-92.

Particularly as the burden of cancer among the elderly increases, it is essential that researchers continue to monitor the affects of major policy changes on Medicare beneficiaries' access to care.

Table 1. Baseline Characteristics of Sample Medicare Beneficiaries*

Variable	2003	2004	*P*†	2005	*P*‡
N	4,975	5,153		4,869	
Mean age, y (sd)	75 (5.6)	75 (5.8)	0.98	75 (5.9)	0.54
Male	2,484 (49.9%)	2,549 (49.5%)	0.64	2,365 (48.6%)	0.37
Race					
White	4,460 (89.6%)	4,605 (89.4%)		4,352 (89.4%)	
Black	352 (7.1%)	397 (7.7%)		366 (7.5%)	
Other/Unknown	163 (3.3%)	151 (2.9%)	0.31	151 (3.1%)	0.84
Cancer Type					
Breast	673 (13.5%)	711 (13.8%)		693 (14.2%)	
Colorectal	1,229 (24.7%)	1,208 (23.4%)		1,087 (22.3%)	
Lung	1,925 (38.7%)	1,968 (38.2%)		1,897 (39.0%)	
Leukemia	288 (5.8%)	334 (6.5%)		295 (6.1%)	
Lymphoma	860 (17.3%)	932 (18.1%)	0.30	897 (18.4%)	0.57
Comorbid conditions					
Ischemic heart disease	1,746 (35.1%)	1,838 (35.7%)	0.55	1,721 (35.3%)	0.74
Hypertension	3,275 (65.8%)	3,608 (70.0%)	<0.0001	3,512 (72.1%)	0.02
Cerebrovascular disease	742 (14.9%)	894 (17.3%)	0.0009	807 (16.6%)	0.30
Dementia	83 (1.7%)	97 (1.9%)	0.42	95 (2.0%)	0.80
Chronic obstructive pulmonary disease	1,949 (39.2%)	2,006 (38.9%)	0.80	1,956 (40.2%)	0.20
Diabetes	1,258 (25.3%)	1,398 (27.1%)	0.04	1,331 (27.3%)	0.82
Peripheral vascular disease	911 (18.3%)	1,003 (19.5%)	0.14	989 (20.3%)	0.29
Renal disease	276 (5.5%)	346 (6.7%)	0.01	317 (6.5%)	0.68
Any malignancy	1,588 (31.9%)	1,611 (31.3%)	0.48	1,464 (30.1%)	0.19
Census region			0.26		0.12
Northeast	986 (19.8%)	972 (18.9%)		1,006 (20.7%)	
South	1,919 (38.6%)	2,085 (40.5%)		1,897 (39.0%)	

Midwest	1,337 (26.9%)	1,359 (26.4%)		1,259 (25.9%)	
West	733 (14.7%)	737 (14.3%)		707 (14.5%)	
Location of first chemotherapy treatment					
Inpatient	333 (6.7%)	354 (6.9%)		320 (6.6%)	
Outpatient	1,030 (20.7%)	1,047 (20.3%)		1,130 (23.2%)	
Physician office	3,612 (72.6%)	3,752 (72.8%)	0.85	3,419 (70.2%)	0.002

* Values are expressed as number (percentage) unless otherwise indicated.

† *P* value for the comparison between calendar years 2003 and 2004.

‡ *P* value for the comparison between calendar years 2004 and 2005.

Table 2. Days From Diagnosis to Initial Chemotherapy and Distance Traveled*

Days	2003	2004	*P*†	2005	*P*‡
Inpatient	18 (9, 41)	17 (7, 32)	0.11	18 (8, 40)	0.17
Outpatient	30 (14, 59)	29 (13, 56)	0.24	31 (14, 58)	0.39
Physician Office	27 (12, 53)	28 (13, 56)	0.05	30 (14, 58)	0.01

Distance (mi)	2003	2004	*P*†	2005	*P*‡
Inpatient	8 (3, 19)	10 (4, 27)	0.02	8 (4, 22)	0.14
Outpatient	6 (2, 15)	7 (3, 19)	0.01	8 (3, 17)	0.91
Physician Office	7 (3, 17)	8 (4, 19)	0.004	9 (4, 20)	0.30

* Values are expressed as median (interquartile range) unless otherwise indicated.

† *P* value for the comparison between calendar years 2003 and 2004.

‡ *P* value for the comparison between calendar years 2004 and 2005.

Table 3. Predictors of Wait Time for Chemotherapy*

Variable	Univariate Model	Multivariable Model†
Age	1.00 (0.99, 1.00)	1.00 (1.00, 1.00)
Sex		
Male	1.08 (1.05, 1.12)	1.01 (0.98, 1.05)
Female	—	—
Race		
White	1.15 (1.08, 1.22)	1.11 (1.04, 1.18)
Other/Unknown	1.20 (1.08, 1.34)	1.21 (1.09, 1.35)
Black	—	—
Cancer Type		
Breast	0.63 (0.60, 0.67)	0.63 (0.59, 0.67)
Colorectal	0.68 (0.65, 0.72)	0.65 (0.62, 0.69)
Leukemia	0.86 (0.80, 0.93)	0.88 (0.82, 0.95)
Lung	0.98 (0.94, 1.03)	0.91 (0.87, 0.95)
Lymphoma	—	—
Ischemic heart disease	0.99 (0.96, 1.02)	0.97 (0.94, 1.01)
Hypertension	0.95 (0.92, 0.99)	0.96 (0.93, 1.00)
Cerebrovascular disease	1.05 (1.01, 1.10)	1.02 (0.98, 1.07)
Dementia	0.93 (0.83, 1.05)	0.93 (0.83, 1.05)
Chronic obstructive pulmonary disease	1.10 (1.07, 1.14)	1.01 (0.98, 1.05)
Diabetes	0.97 (0.94, 1.01)	1.00 (0.96, 1.04)
Peripheral vascular disease	1.01 (0.97, 1.05)	0.96 (0.92, 1.01)
Renal disease	1.04 (0.98, 1.12)	1.03 (0.96, 1.10)
Any malignancy	1.60 (1.54, 1.65)	1.59 (1.53, 1.64)
Region		
Midwest	1.04 (0.99, 1.09)	1.04 (0.98, 1.09)
Northeast	0.93 (0.88, 0.98)	0.92 (0.87, 0.97)
South	1.03 (0.98, 1.08)	1.04 (0.99, 1.09)
West	—	—
Year of incidence and treatment		
2003	1.02 (0.98, 1.06)	1.03 (0.99, 1.07)
2004	—	—
2005	0.97 (0.94, 1.01)	0.98 (0.94, 1.02)

* Values are expressed as the hazard ratio (95% confidence interval).

Note: The hazard ratios estimate the effect of a given covariate on days to treatment. Consequently, hazard ratios in excess of 1.0 suggest shorter wait times as compared to the referent group while hazard ratios less than 1.0 imply longer wait times.

Values in blue text represent significantly longer wait times; values in red text represent significantly shorter wait times ($p<.05$).

† The multivariable model controlled for age, sex, race, cancer type, geographic region, comorbid conditions, and year of incidence and treatment.

Table 4. Predictors of Distance Traveled for Chemotherapy*

Variable	Univariate Model	Multivariable Model†
Age	-0.20 (-0.24, -0.15)	-0.18 (-0.23, -0.13)
Sex		
Male	0.51 (-0.05, 1.07)	0.46 (-0.13, 1.06)
Female	—	—
Race		
White	3.73 (2.66, 4.80)	4.62 (3.55, 5.69)
Other/Unknown	1.51 (-0.39, 3.41)	3.35 (1.45, 5.24)
Black	—	—
Cancer Type		
Breast	-0.01 (-1.01, 1.00)	0.32 (-1.35, 0.71)
Colorectal	-0.03 (-0.91, 0.85)	0.02 (-0.86, 0.89)
Leukemia	3.33 (2.01, 4.64)	3.31 (2.01, 4.60)
Lung	0.80 (0.00, 1.61)	0.22 (-0.61, 1.05)
Lymphoma	—	—
Ischemic heart disease	-0.53 (-1.12, 0.06)	-0.20 (-0.83, 0.44)
Hypertension	-0.62 (-1.23, -0.01)	0.02 (-0.62, 0.66)
Cerebrovascular disease	-0.65 (-1.41, 0.12)	-0.57 (-1.36, 0.21)
Dementia	0.53 (-1.57, 2.62)	1.69 (-0.40, 3.77)
Chronic obstructive pulmonary disease	0.29 (-0.29, 0.86)	0.03 (-0.58, 0.64)
Diabetes	-1.13 (-1.77, -0.49)	-0.92 (-1.57, -0.26)
Peripheral vascular disease	-0.89 (-1.60, -0.18)	-0.48 (-1.22, 0.27)
Renal disease	-0.99 (-2.15, 0.17)	-0.21 (-1.38, 0.96)
Any malignancy	0.24 (-0.37, 0.85)	0.50 (-0.12, 1.11)
Region		
Midwest	2.64 (1.73, 3.55)	2.72 (1.81, 3.64)
Northeast	-2.28 (-3.24, -1.32)	-2.08 (-3.05, -1.12)
South	4.31 (3.46, 5.17)	4.55 (3.69, 5.42)
West	—	—
Year of incidence and treatment		
2003	-1.65 (-2.34, -0.97)	-1.62 (-2.29, -0.94)
2004	—	—
2005	-0.32 (-1.00, 0.37)	-0.19 (-0.86, 0.49)

* Values are expressed as the parameter estimate (95% confidence interval).

Values in blue text represent significantly longer travel distances; values in red text represent significantly shorter travel distances ($p<.05$).

† The multivariable model controlled for age, sex, race, cancer type, geographic region, comorbid conditions, and year of incidence and treatment.

Appendix A. ICD-9-CM Codes Used to Identify Cancer

Tumor Type	Diagnostic Codes (ICD-9)
Breast	174.0-174.9, 175.0-175.9, 233.0, V10.3
Colorectal	153.0-153.9, 154.0-154.8, 230.3-230.6, 159.0, V10.05, V10.06
Leukemia	200.00-200.88, 202.00-202.28, 202.80-202.98, V10.71, V10.79
Lung	162.2-162.9, 231.2, V10.11
Lymphoma	202.40-202.48, 203.10, 204.00, 204.10, 204.20, 204.80, 204.90, 205.00, 205.10, 205.20, 205.80, 205.90, 206.00, 206.10, 206.20, 206.80, 206.90, 207.00, 207.10, 207.20, 207.80, 208.00, 208.10, 208.20, 208.80, 208.90, V10.60-V10.63, V10.69

Abbreviations: ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

Appendix B. ICD-9-CM Codes Used to Identify Chemotherapy Claims

Variable	Specific Codes	File(s)
ICD-9-CM Diagnosis	V58.1	Inpatient Outpatient Carrier
ICD-9-CM Procedure	99.25	Inpatient Outpatient
CPT-4/HCPCS	96400-96549, G0345-G0362, Q0083-Q0085, J8510-J9999	Outpatient Carrier
HCPCS	J8510-J9999	Durable Medical Equipment

Abbreviations: ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*. CPT, *Current Procedural Terminology, Fourth Edition.* HCPCS, *Healthcare Common Procedure Coding System, Level II, National Codes.*