MILLIMAN CLIENT REPORT

Survival of Medicare Fee-for-Service Chemotherapy Patients by Site of Care

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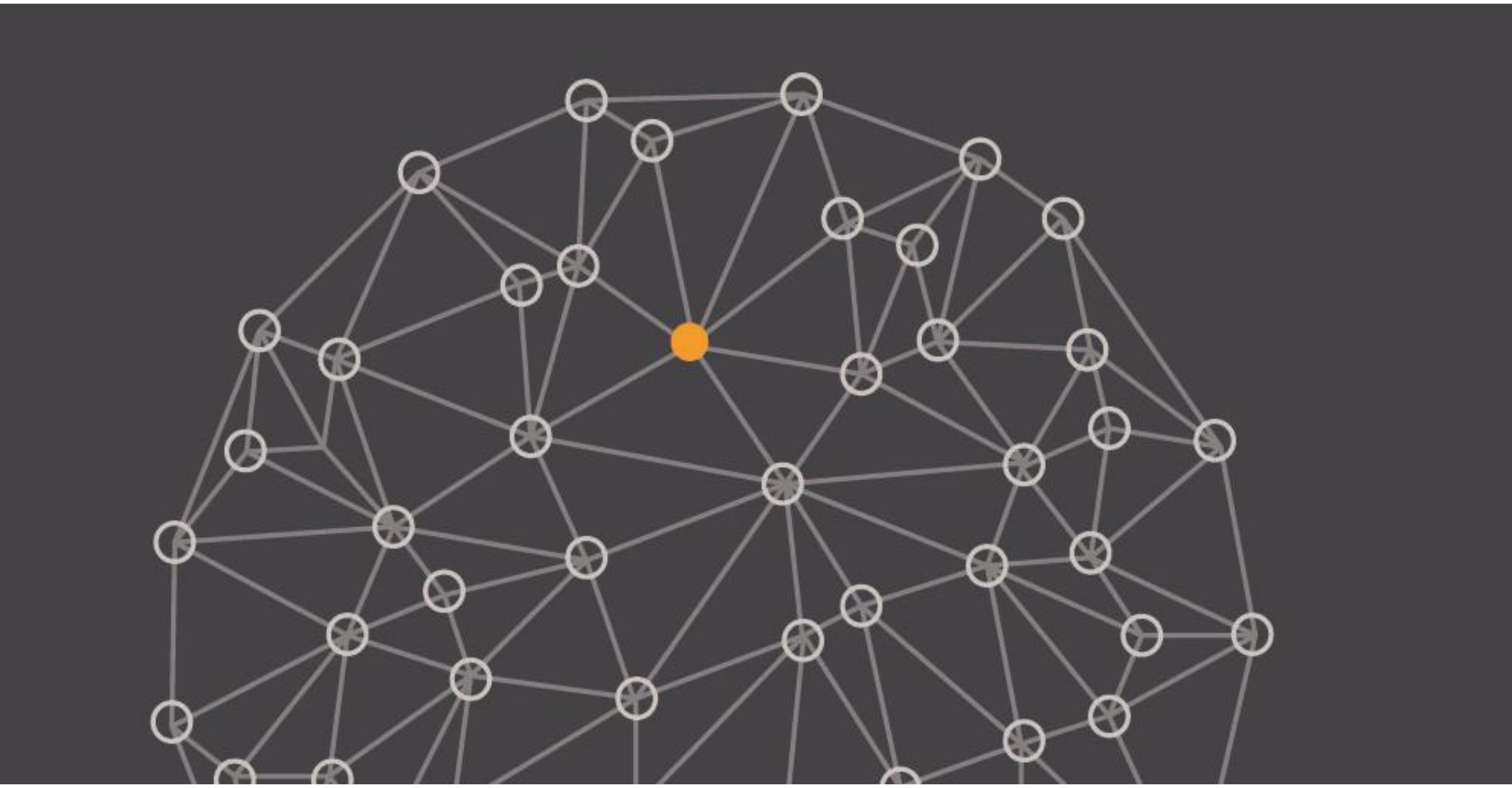
Commissioned by the Alliance of Dedicated Cancer Centers



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Executive Summary

Cancer is the second leading cause of death in the United States.[1] Because of the large number of cancer diagnoses and deaths each year, studies of cancer survival are of interest to physicians, patients, and health services researchers alike. Prior studies on cancer patients have examined survival based on treatment in one particular type of facility, but few compare outcomes across multiple cancer treatment facility types simultaneously.[2,3]

This report compares the 36-month survival by treatment facility type for 46,762 Medicare fee-for-service patients treated with chemotherapy covered under the Medicare Part B benefit for breast, colon, lung, ovarian, pancreatic, or prostate cancer. The report compares prospective payment system (PPS)-exempt cancer hospitals to three other facility types: National Cancer Institute (NCI)-designated cancer centers, teaching hospitals, and all other hospitals.

This paper describes the following major findings:

- Patients treated at PPS-exempt cancer hospitals have lower risk of dying within 36 months than patients treated at other types of hospitals by 17% to 33%.

Across all cancer types examined, differences in survival at PPS-exempt cancer hospitals as compared to other facility types were statistically significant. When examining survival outcomes by cancer type, this remained true for 4 of the 6 cancer types analyzed. We find that patients under active treatment at PPS-exempt cancer hospitals have statistically significant better all-cause survival compared to patients treated at other sites of care.

- The risk adjustment mechanism employed in this study identifies relevant cost differences among patients.

We risk adjust patients using the Clinical Risk Groups (CRGs) developed by 3M®, which are intended to describe the extent and progression of the disease (with a higher treatment level indicating a higher degree of treatment difficulty).[4] The average cost per month survived varies significantly by CRG treatment level, which supports the use of this risk adjustment metric.

- PPS-exempt cancer hospitals treat sicker patients than other types of hospitals (as defined by patients' CRG levels).

Patients treated in PPS-exempt cancer hospitals were, on average, sicker than those patients treated in other settings, when measured using the percent of episodes in a higher treatment level. Among the sample of patients treated in PPS-exempt cancer hospitals, 64% were in the two highest levels of treatment compared to 56%-58% of patients for the other three sites of care.

As with any economic or actuarial analysis, it is not possible to capture all factors that may be significant. These findings represent survival outcomes for only 36 months, which may not be indicative of longer term cancer-related mortality. Furthermore, findings should be interpreted cautiously as survival is one of many metrics for the quality of care. While administrative claims data is a powerful tool to research cancer treatment outcomes, such data does not include important clinical factors such as cancer stage or tumor histology.

Because we present average data based on national databases, the findings should be interpreted carefully before they are applied to any particular situation. The data examined lacks information on carrier or durable medical equipment (DME) claims, thereby limiting the ability to analyze carrier or DME costs and utilization and restricting this analysis to hospital-based chemotherapy episodes. We included chemotherapy covered under Medicare Part A and Part B, but not Part D (oral chemotherapy) due to data limitations.

This report was commissioned by the Alliance of Dedicated Cancer Centers (ADCC), an organization with 11 member institutions whose sole mission is treating cancer patients. The ADCC advocates for the greatest possible access to their centers for all patients, and its member institutions are all exempt from payment under the typical inpatient prospective payment system used to pay for services provided to Medicare fee-for-service beneficiaries. The findings and conclusions reflect the opinion of the authors; Milliman does not endorse any policy. Findings for particular populations and for different time periods will vary from these findings. Bruce Pyenson is a member of the American Academy of Actuaries and meets its qualifications for this work.

Background

Cancer is the second leading cause of death in the United States[1] and accounted for 21.6% of all deaths in 2015. In 2016, there were an estimated 1.685 million new cases of cancer and 595,690 cancer deaths.[5] Survival and other treatment outcomes are a key consideration when cancer patients select a treatment center upon diagnosis.[6] A national survey reports that 94% of cancer patients regard good treatment results as “extremely” or “very” important in their selection of treatment facility. [7] It can be difficult for patients to find this information when they are considering the many different settings in which they can receive cancer treatment – in order for survival statistics to be defensible and relevant, they must take into account the substantial variation in the types of patients who are being measured. Prior outcomes studies on cancer patients have examined survival based on treatment in one particular type of facility, but few compare outcomes across multiple cancer treatment facility types simultaneously.[2,3]

Type of treatment facility might play a role in survival outcomes among patients with cancer, with literature stating that facilities treating a higher volume of cancer patients and offering specialized treatment are associated with better survival outcomes.[8,9,10] One study of Medicare beneficiaries diagnosed with advanced head and neck cancers indicated near statistically significant better survival at facilities treating a large portion of advanced head and neck cancer patients as compared to facilities treating a small volume of patients for the same disease.[9] An additional study found statistically significant better five-year survival for non-Hodgkin lymphoma patients when treated at teaching hospitals as compared to other types of community facilities and also when treated by higher volume hospitals compared to lower volume hospitals.[11]

While common sense dictates that facilities exclusively dedicated to the treatment of cancer will generally be high volume in terms of their cancer patients, other teaching hospitals also treat a significant share of patients with cancer. For this analysis, we compared survival in PPS-exempt cancer hospitals to survival in three other distinct types of treatment facilities. All four of these facility types are defined below:

- *Prospective Payment System–Exempt Cancer Hospitals*: Hospitals that are excluded from the prospective payment system (PPS) that is typically used by the Centers for Medicare and Medicaid Services (CMS) to pay for inpatient services.[12] PPS-exempt cancer hospitals were designated beginning in 1983. At that time, congress designated eight cancer centers to be exempt from the newly-created inpatient prospective payment system (IPPS). This has since expanded to 11 facilities.[13]
- *National Cancer Institute (NCI)-designated Comprehensive Cancer Centers*: Hospitals (other than PPS-exempt cancer hospitals) that are designated as comprehensive cancer centers which receive support from the National Cancer Institute for cancer research and which care for patients directly.[14]
- *Teaching Hospitals:* Hospitals (other than PPS-exempt cancer hospitals and NCI-designated comprehensive cancer centers) that have active residency programs, defined based on their receipt of indirect medical education (IME) payments from CMS.

- *All Other Hospitals:* Any hospital that does not meet any of the three criteria above.

The objective of this analysis is to report three-year survival outcomes for Medicare Fee-for-service patients being treated for breast, colon, lung, ovarian, pancreatic, or prostate cancer with chemotherapy covered under the Medicare Part B benefit between 2010 and 2011. For this analysis, we used the Medicare 100% and 5% Limited Data Set (LDS) files, which include details on claims paid by Medicare on behalf of beneficiaries eligible for Part A and Part B. We risk adjust patients using the Clinical Risk Groups (CRGs) developed by 3M®, which has been examined as an analytic tool for cancer studies using claims data when stage is not available.[15] For more details on our methodology, see the Methodology and Data Sources section.

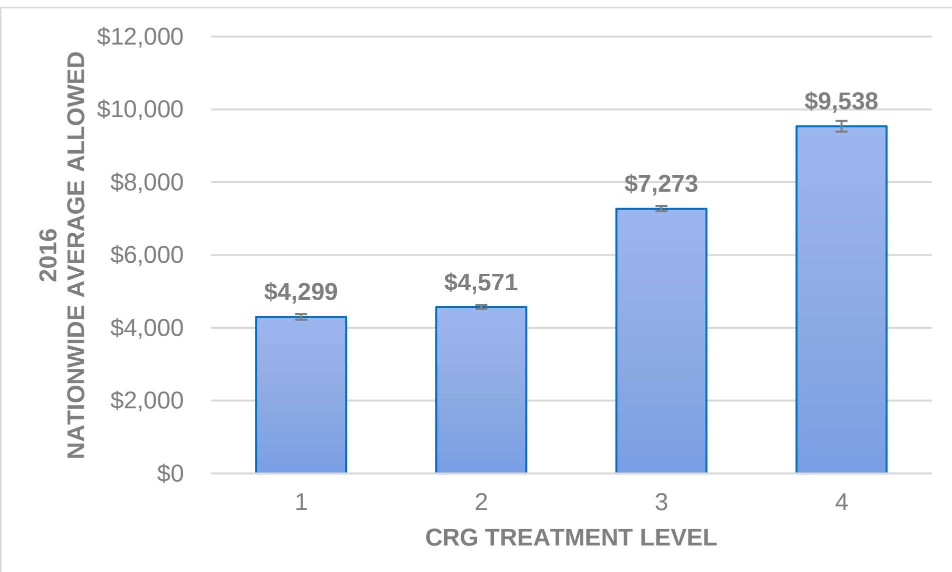
Findings

PATIENT SEVERITY

While clinical characteristics such as stage of cancer, presence of metastases, and gene expression are important factors when determining the severity of cancer,[16,17,18] this level of detail is not typically available in administrative claims data. To account for patient severity across sites of care, we use the Clinical Risk Group (CRG) risk adjustment model developed by 3M®, which assigns severity levels to individual patients based on their claims data.

We analyzed average per-patient cost differences across all cancers and sites of care for each CRG treatment level. Figure 1 provides a distribution of average Medicare allowed cost (amounts paid by both Medicare and the patient combined) per month survived. Medicare fees change over time and vary by region and facility. Costs in Figure 1 have been converted to nationwide average fee levels for 2016. This conversion allows for geographic- and facility-neutral comparison that indicates differences in utilization while compensating for disparities in payment structure.

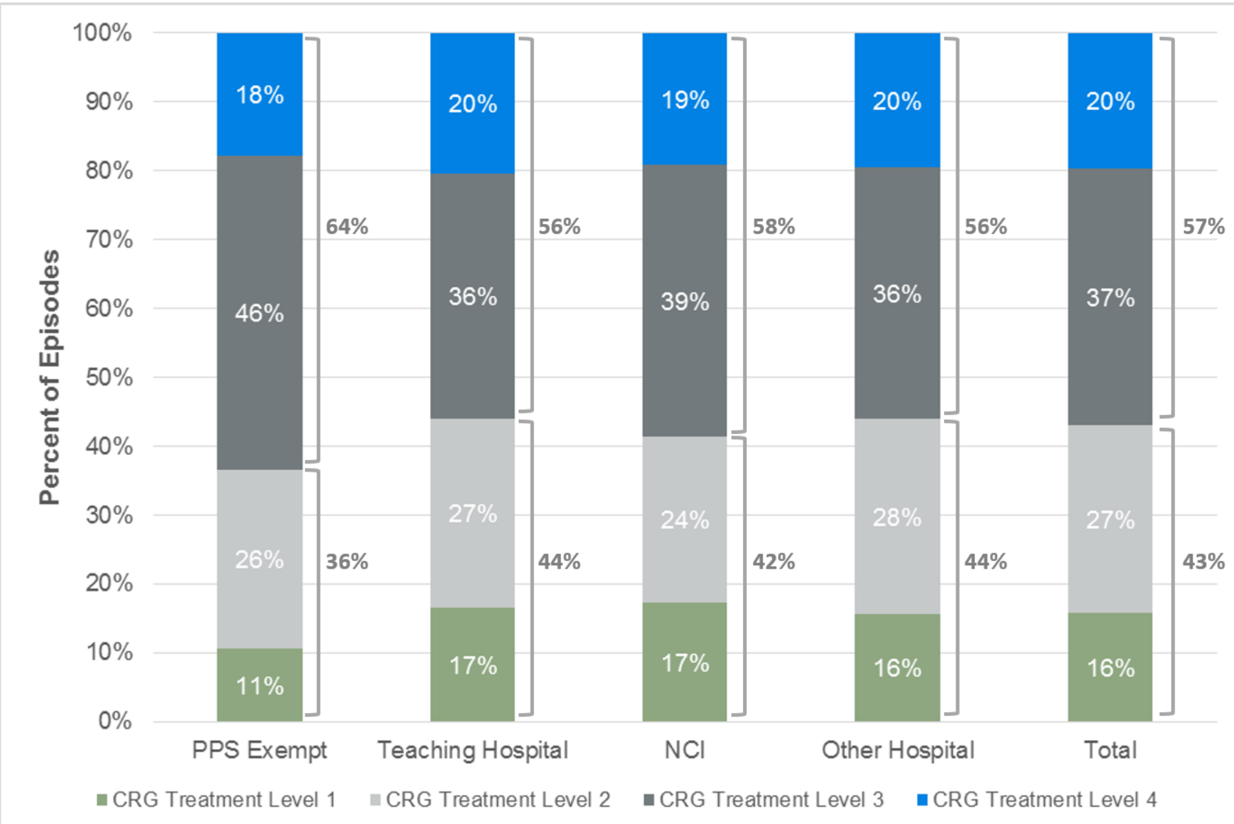
FIGURE 1: AVERAGE COST PER MONTH SURVIVED BY TREATMENT LEVEL



Source: Milliman analysis of the Medicare 100% and 5% limited data sets for 2010-2014

The increasing cost with CRG treatment level is consistent with expectations of higher cost for patients with higher severity. PPS-exempt cancer hospitals have a more severe mix of patients when compared to other sites, with a higher portion of patients in CRG treatment levels 3 and 4 than the other sites. Figure 2 presents a distribution of episodes by CRG treatment level across all cancers for each site of care. Differences in the distribution by site are statistically significant (p<.05).

FIGURE 2: DISTRIBUTION OF CRG TREATMENT LEVEL BY CARE SETTING



	PPS-EXEMPT		TEACHING HOSPITAL		NCI		OTHER HOSPITAL		TOTAL		
CRG Treatment Level	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**p***
Treatment Level 1	443	11%	3,592	17%	659	17%	2,599	16%	7,293	16%	
Treatment Level 2	1,072	26%	5,932	27%	917	24%	4,738	28%	12,659	27%	
Treatment Level 3	1,883	46%	7,756	36%	1,502	39%	6,054	36%	17,195	37%	
Treatment Level 4	735	18%	4,407	20%	728	19%	3,255	20%	9,125	20%	
Total	**4,133**	**100%**	**21,687**	**100%**	**3,806**	**100%**	**16,646**	**100%**	**46,272**	**100%**	**<.0001**

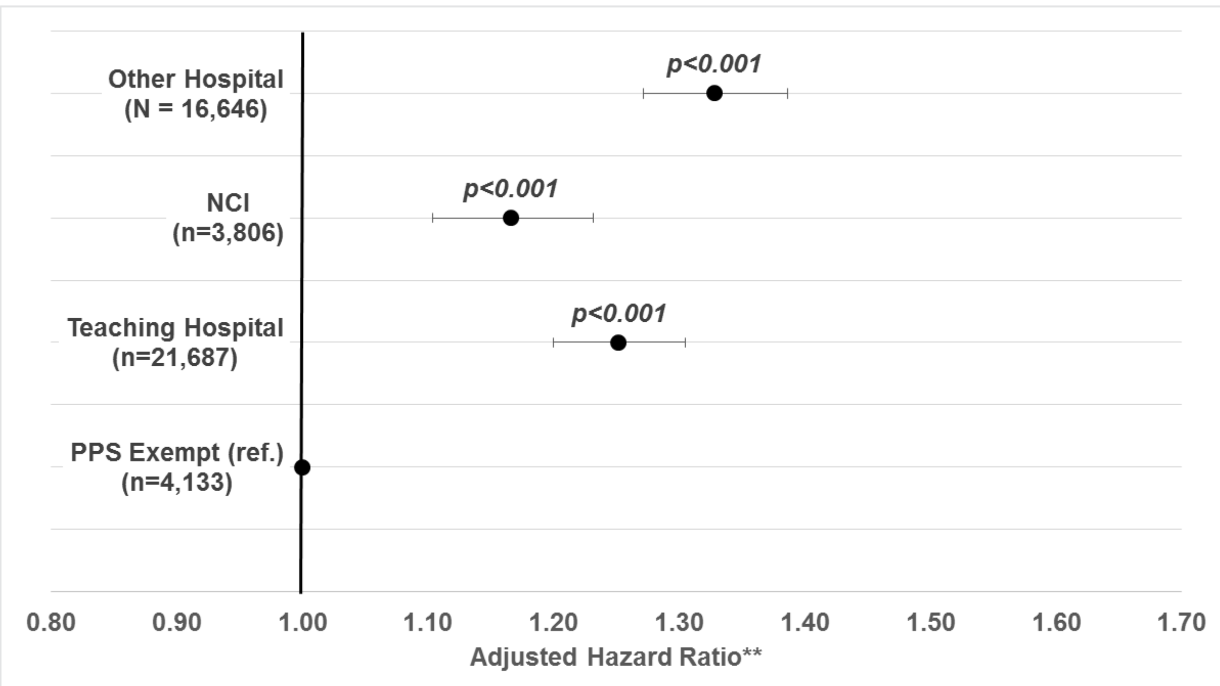
*P-value from Chi-squared analysis. Does not adjust for varying cancer type mixes across care settings.
Source: Milliman analysis of the Medicare 100% and 5% limited data sets for 2010-2014

Based on the findings from this analysis, we find the CRGs an appropriate explanatory variable for patients. As such, we move forward with using CRGs as a risk adjustment mechanism.

SURVIVAL

We examined survival across the patient populations treated in each of the four sites of care using Cox proportional hazards models[19,20] to determine the probability of all-cause mortality. Using the PPS-exempt cancer hospitals as our reference group, we compared survival in that setting to that of the other three hospital types examined. We tracked patients from the date of service of the first Medicare Part B chemotherapy claim with follow-up limited to the earlier of 36 months or date of death. We applied a multivariate approach using the following covariates: CRG treatment level, gender, cancer type, patient age, and dual eligibility status (patients eligible for Medicaid benefits as well as Medicare Part A and Part B). Figure 3A presents the hazard ratios across all 6 cancers for each site of care. For these analyses, the PPS-exempt cancer hospitals hazard ratio is considered the reference point and is set to 1.00. Increased hazard ratios indicate a higher likelihood of mortality. Statistical significance is established when both a p-value is less than .05 and the 95% confidence intervals for non-PPS exempt cohorts do not overlap with the PPS-exempt cancer hospital reference point of 1.00.

FIGURE 3A: MULTIVARIATE COX PROPORTIONAL HAZARDS ANALYSIS OF OVERALL SURVIVAL BY CARE SETTING*



* P-value associated with the Wald statistic.

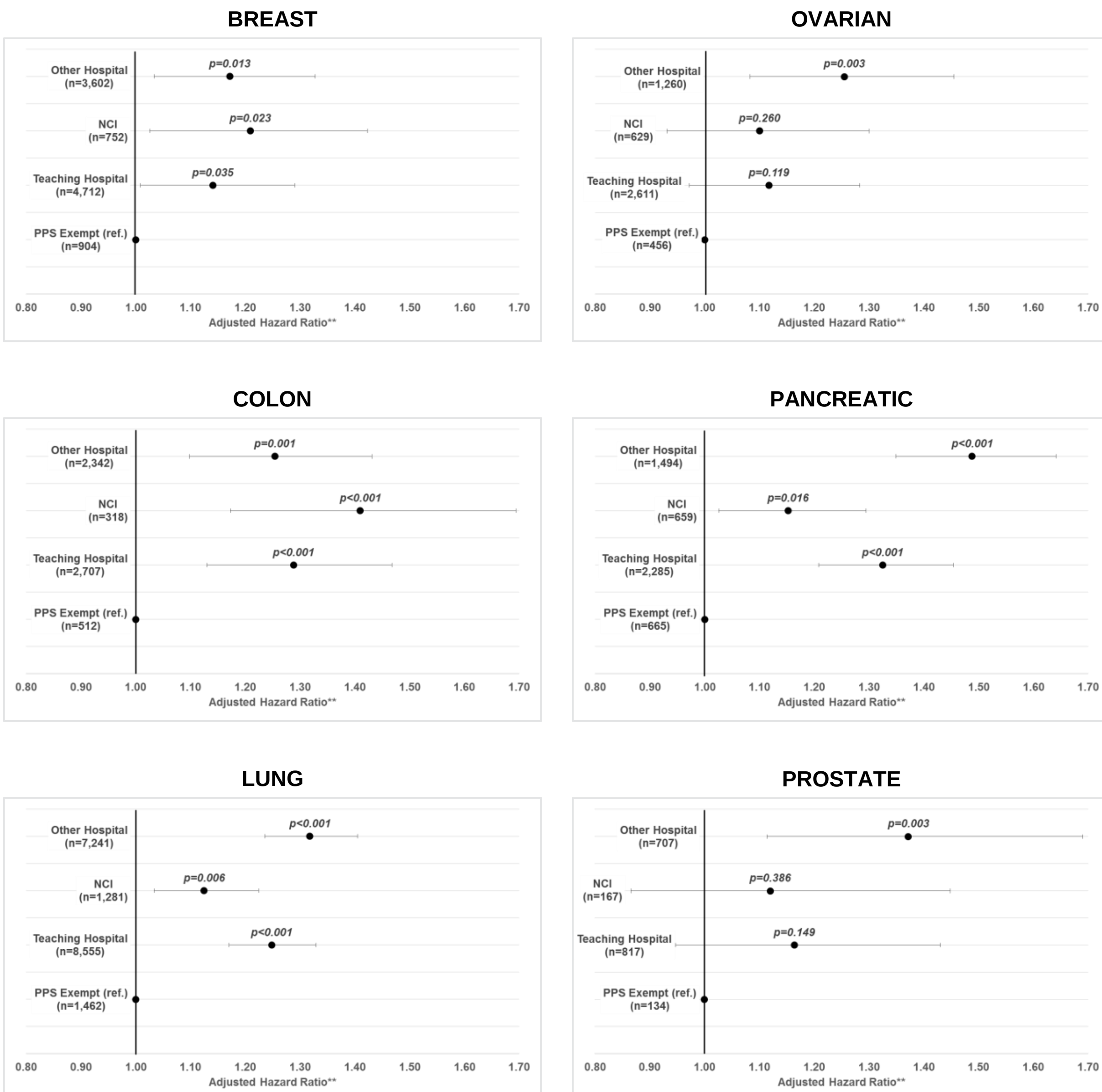
**Brackets represent the 95% confidence interval of adjusted hazard ratio. Increased Hazard Ratios indicate a higher likelihood of mortality.

Source: Milliman analysis of the Medicare 100% and 5% limited data sets for 2010-2014

We find that patients under active treatment at PPS-exempt cancer hospitals have statistically significant better all-cause survival compared to patients treated at other sites of care. After controlling for treatment level, sex, dual status, age, and cancer type, patients treated in NCI-designated cancer centers have 17% greater odds of dying within 36 months compared to patients treated in PPS-exempt cancer centers. Likewise, patients treated in teaching hospitals and other hospitals have 25% and 33% greater odds of dying, respectively.

Survival by cancer type (Figure 3B) was generally similar to the overall population results. We found that episodes treated in PPS-exempt cancer hospitals have higher survival with statistical significance for breast, colon, lung, and pancreatic cancers.

FIGURE 3B: MULTIVARIATE COX PROPORTIONAL HAZARDS ANALYSIS OF OVERALL SURVIVAL BY CARE SETTING AND CANCER



* P-value associated with the Wald statistic.

**Brackets represent the 95% confidence interval of adjusted hazard ratio. Increased Hazard Ratios indicate a higher likelihood of mortality.

Source: Milliman analysis of the Medicare 100% and 5% limited data sets for 2010-2014

After adjusting for patient severity, patients treated in PPS-exempt cancer hospitals with breast, colon, lung, and pancreatic cancers had higher survival which was significant (hazard ratios with both $p<.05$ and non-overlapping confidence intervals). Noting a wide variation in survival outcomes as indicated by the calculated 95% confidence intervals, breast cancer patients treated at teaching hospitals, NCI-designated cancer centers, and other hospitals reported 14%, 21%, and 17% respectively higher odds of death as compared to those treated by PPS-exempt cancer centers. The difference for colon cancer was more pronounced reporting 29%, 41%, and 25% increased odds of death when compared to the PPS-exempt cohort. Calculations for lung and pancreatic cancers reported less variability, and indicated PPS-exempt cancer centers as the leader in survival outcomes by as much as 32% for lung and 49% for pancreatic. For patients with ovarian and prostate cancers, survival was not different for patients treated in PPS-exempt cancer hospitals as compared to other sites.

Implications

A newly diagnosed cancer patient will value reporting of survival outcomes when selecting a treatment facility. Cancer patients are a highly diverse group, with variation in terms of cancer type, stage, and complexity. Our analysis finds that different types of facilities have variation in the severity mix of their patients, and as such risk adjustment plays a critical role comparing survival outcomes across sites of care.

This analysis provides evidence that Medicare FFS cancer patients receiving chemotherapy covered under the Medicare Part B benefit at PPS-exempt cancer hospitals may experience improved odds of survival compared to patients treated at other hospital types. While our analysis was for only 6 cancer types, the cancers we examined include the most important cancers from the standpoint of mortality and incidence.

This study provides compelling information, but it is not a complete story. Because cancer therapies are changing, in the future readers will want to see the analysis using updated data. In addition, many chemotherapy patients are covered by commercial insurance. These patients tend to be younger than the patients examined in this study, and the fee-levels are both higher and structured differently than Medicare's. Treatment modalities other than chemotherapy are important for cancer patients, and the study could be extended to those patients. Finally, as additional data sources become available, we believe it will soon be possible to bring into the analysis patients who receive chemotherapy in physician offices.

Limitations

As with any economic or actuarial analysis, it is not possible to capture all factors that may be significant. Because we present average data based on the 2010-2014 Medicare 5% and 100% Limited Data Set (LDS), which are national databases, the findings should be interpreted carefully before they are applied to any particular situation. We included chemotherapy covered under Medicare Part A and Part B, but not Part D (oral chemotherapy) due to data limitations.

Chemotherapy is often provided in a physician's office. Due to data limitations, patients who received their chemotherapy exclusively within a physician office were not included in this analysis. Additionally, it is possible that some episodes that were attributed to a hospital in this analysis actually included some physician office based chemotherapy, which was not identified due to the lack of physician claims in the 100% LDS. Based on our analysis of episodes that overlapped between the 5% and 100% LDS, we believe this only affected a small minority (approximately 0.3%) of cases. Physician office based episodes of care could be identified using the CMS 5% LDS, but because of the difference in claims availability, the assignment of CRGs for risk adjustment purposes was not comparable to episodes of care identified in the 100% LDS. Please refer to the Methodology section of this paper for more details.

While administrative claims data is a powerful tool to research cancer treatment outcomes, such data does not include important clinical factors such as cancer stage or tumor markers. Cancer patients represent a wide spectrum of severity, type, stage, and receive varying treatments. Survival rates can reflect a "lead time bias" where patients diagnosed early have better outcomes than those diagnosed at advanced stages.[21] We employed the 3M® Clinical Risk Groups (CRGs) to measure and adjust for cancer acuity. This analysis demonstrates that the CRGs stratify patients into groups with significant differences in cost, which is consistent with the performance expectations of a prospective risk adjuster for cost. Because CRG assignment was based on the 100% LDS, we are likely missing some claims for cancer treatments occurring in physician offices or paid under the DME fee schedule. We have accounted for this issue by only including CRGs that indicate active treatment for cancer, but this limitation may still bias our results towards lower acuity CRGs.

These findings represent survival outcomes for only 36 months, which may not be indicative of longer term cancer-related mortality.

Our analysis included Medicare fee-for-service cancer patients initializing chemotherapy treatment in 2010 or 2011. Analysis of different time periods or populations, such as non-Medicare populations, may yield different results. The latest year analyzed in this report is 2014 and does not reflect advances in cancer treatments after that time. Oral chemotherapy covered under Part D, which is growing in importance, was not included in this analysis.

Sources and Methodology

DATA

Medicare 5% and 100% Limited Data Set (LDS)

These are limited data sets containing Medicare paid claims generated by fee-for-service Medicare beneficiaries within the time period. Information includes county of residence, diagnosis codes, procedure codes, DRG codes, site of service information, beneficiary age, eligibility status and an indicator for HMO enrollment. Member identification codes are consistent from year to year and allow for multiyear longitudinal studies. The Medicare 100% sample data does not include carrier, DME, or Part D prescription drug data. The Medicare 5% sample additionally includes carrier and DME for a statistically-balanced sample of Medicare fee-for-service beneficiaries. We used 2009-2014 data for this analysis.

Due to the lack of carrier and DMEPOS claims in the Medicare 100% sample, claims data from the Medicare 5% sample was used to estimate the additional utilization that physician and DME claims contributed to episodes. The subset of episodes with overlapping claims data in both the Medicare 5% and 100% samples was used to develop per member per month gross up factors that were then applied to all episodes to estimate total utilization.

DETAILED METHODOLOGY

Identification of Study Population

Actively Treated for Cancer

We identify patients who are actively being treated for cancer with chemotherapy infusions, beginning their treatment in either 2010 or 2011. We defined actively treated patients as reporting two or more claims with chemotherapy drug HCPCS codes occurring within six months of each other. Beneficiaries receiving chemotherapy were required to have a 12 month “clean period” (no chemotherapy) prior to the initiating chemotherapy claim to begin an episode of care.

The date of service of the first Medicare Part B chemotherapy code in either 2010 or 2011 was designated as the episode start date. HCPCS codes used to identify chemotherapy are detailed below.

TABLE 1: CHEMOTHERAPY HCPCS CODES

A9543	C9292	J9019	J9055	J9110	J9200	J9226	J9280	J9328	J9600
A9545	C9295	J9020	J9060	J9120	J9201	J9228	J9290	J9330	J9999
C9021	C9296	J9025	J9062	J9130	J9202	J9230	J9291	J9340	Q2017
C9025	C9297	J9027	J9065	J9140	J9206	J9245	J9293	J9350	Q2043
C9027	C9442	J9031	J9070	J9150	J9207	J9250	J9299	J9351	Q2048
C9131	C9449	J9032	J9080	J9151	J9208	J9260	J9300	J9354	Q2049
C9257	C9453	J9033	J9090	J9155	J9211	J9261	J9301	J9355	
C9259	C9455	J9035	J9091	J9160	J9212	J9262	J9302	J9357	
C9260	J0202	J9039	J9092	J9165	J9213	J9263	J9303	J9360	
C9265	J0894	J9040	J9093	J9170	J9214	J9264	J9305	J9370	
C9273	J9000	J9041	J9094	J9171	J9215	J9265	J9306	J9371	
C9276	J9001	J9042	J9095	J9178	J9216	J9266	J9307	J9375	
C9280	J9002	J9043	J9096	J9179	J9217	J9267	J9308	J9380	
C9284	J9010	J9045	J9097	J9181	J9218	J9268	J9310	J9390	
C9287	J9015	J9047	J9098	J9185	J9219	J9270	J9315	J9395	
C9289	J9017	J9050	J9100	J9190	J9225	J9271	J9320	J9400	

Cancer Type

Chemotherapy patients were required to be diagnosed with a cancer of interest to be included in the study. Cancers of interest included breast, colon, lung, ovarian, pancreatic, and prostate. Claims incurred in the 12 months prior to and six months following the episode start date were reviewed. A patient was determined to be diagnosed with a cancer if they reported the cancer's diagnosis code in any position on either one or more inpatient, observation, or chemotherapy administration visits or two or more emergency department, non-acute inpatient, or outpatient claims on different dates of service. Patients identified for more than one cancer of interest were removed from this analysis.

TABLE 2: IDENTIFICATION CODES

CLAIM TYPE	CODE TYPE	VALUES
BREAST CANCER	DIAGNOSIS CODE	174.XX, 233.0
COLON CANCER	DIAGNOSIS CODE	153.XX
LUNG CANCER	DIAGNOSIS CODE	162.XX
OVARIAN CANCER	DIAGNOSIS CODE	183.0
PANCREATIC CANCER	DIAGNOSIS CODE	157.XX
PROSTATE CANCER	DIAGNOSIS CODE	185.XX
OUTPATIENT CLAIMS	CPT CODE	99201-99205, 99211-99215, 99241-99245, 99341-99345, 99347-99350, 99384-99387, 99394-99397, 99401-99404, 99411, 99412, 99420, 99429, 99455, 99456
OUTPATIENT CLAIMS	REVENUE CODE	051X, 0520-0523, 0526-0529, 057X-059X, 082X-085X, 088X, 0982, 0983
NON-ACUTE INPATIENT CLAIMS	CPT CODE	99304-99310, 99315, 99316, 99318, 99324-99328, 99334-99337
NON-ACUTE INPATIENT CLAIMS	REVENUE CODE	0118, 0128, 0138, 0148, 0158, 019X, 0524, 0525, 055X, 066X
ACUTE INPATIENT CLAIMS	CPT CODE	99221-99223, 99231-99233, 99238, 99239, 99251, 99255, 99291
ACUTE INPATIENT CLAIMS	REVENUE CODE	010X, 0110-0114, 0119, 0120-0124, 0129, 0130-0134, 0139, 0140-0144, 0149, 0150-0154, 0159, 016X, 020X, 021X, 072X, 080X, 0987
OBSERVATION CLAIMS	CPT CODE	99217-99220, 99224-99226
EMERGENCY DEPARTMENT CLAIMS	CPT CODE	99281-99285
EMERGENCY DEPARTMENT CLAIMS	REVENUE CODE	0450-0452,0456,0459, 0981
CHEMOTHERAPY ADMINISTRATION	CPT CODE	96401, 96402, 96405, 96406, 96410, 96411, 96413, 96415, 96416, 96417, 96420, 96422, 96423, 96425, 96440, 96445, 96446, 96450, 96542, 96549

Eligibility Requirements

Beneficiaries were excluded from the study if they met any of the following conditions:

- Beneficiaries reporting a Medicare eligibility status for the ESRD program at any point in 2009-2014.
- Lack of continuous Part A and B, non-HMO (Medicare Advantage) coverage during any part of the analysis period – 12 months preceding the episode start date through 36 months following (or until date of death if earlier).

Site of Care

Episodes of care were then assigned to one of four cohorts based on site of chemotherapy treatment using the following hierarchy: PPS-exempt cancer hospitals, NCI-designated comprehensive cancer centers, teaching hospitals, and other hospitals. PPS-exempt cancer hospitals and NCI-designated comprehensive cancer centers were identified by CMS Certification Number (CCN), as shown in Tables 3 and 4. Note that while the NCI designates several types of facilities, our category contains only those NCI-designated facilities which were designated as comprehensive cancer centers (45 facilities).[22] Nine of the 45 facilities were included in our PPS-exempt cohort and the remaining 36 were included as NCI-designated comprehensive cancer centers. Teaching hospitals were identified using the inpatient prospective payment system (IPPS) public use impact files from CMS.gov.[23,24] All remaining hospitals were assigned to the “other hospital” cohort. Patients were included in the care setting where more than 50% of infused chemotherapy services in the first six months following the episode start date were incurred.

TABLE 3: PPS-EXEMPT CANCER HOSPITALS

CANCER CENTER	CCN
AMERICAN ONCOLOGIC HOSPITAL (FOX CHASE)	390196
AUTHUR G. JAMES CANCER HOSPITAL AND RESEARCH INSTITUTE	360242
CITY OF HOPE NATIONAL MEDICAL CENTER	050146
DANA-FARBER CANCER INSTITUTE	220162
H. LEE MOFFITT CANCER CENTER & RESEARCH INSTITUTE HOSPITAL	100271
MEMORIAL HOSPITAL FOR CANCER AND ALLIED DISEASE	330154
ROSWELL PARK MEMORIAL INSTITUTE	330354
SEATTLE CANCER CARE ALLIANCE	500138
SYLVESTER COMPREHENSIVE CANCER CENTER	100079
THE UNIVERSITY OF TEXAS M.D. ANDERSON CANCER CENTER	450076
USC KENNETH NORRIS JR. CANCER HOSPITAL	050660

TABLE 4: NCI-DESIGNATED COMPREHENSIVE CANCER CENTERS

CANCER CENTER	CCN
ABRAMSON CANCER CENTER	390111
ALVIN J. SITEMAN CANCER CENTER	260032
ARIZONA CANCER CENTER	030064
BARBARA ANN KARMANOS CANCER INSTITUTE	230297
CASE COMPREHENSIVE CANCER CENTER	360137
CHAO FAMILY COMPREHENSIVE CANCER CENTER	050348
DAN L DUNCAN COMPREHENSIVE CANCER CENTER (BEN TAUB GENERAL HOSPITAL)	450289
DAN L DUNCAN COMPREHENSIVE CANCER CENTER (TEXAS CHILDREN'S HOSPITAL)	453304
DUKE CANCER INSTITUTE	340030
FRED HUTCHINSON / UNIVERSITY OF WASHINGTON CANCER CONSORTIUM	500008
GEORGETOWN LOMBARDI COMPREHENSIVE CANCER CENTER	090004
HAROLD C. SIMMONS COMPREHENSIVE CANCER CENTER	450044
HERBERT IRVING COMPREHENSIVE CANCER CENTER	330101
HOLDEN COMPREHENSIVE CANCER CENTER	160058
HUNTSMAN CANCER INSTITUTE	460009
JONSSON COMPREHENSIVE CANCER CENTER	050262

MASONIC CANCER CENTER	240049
MAYO CLINIC CANCER CENTER	030103
MAYO CLINIC CANCER CENTER	100151
MAYO CLINIC CANCER CENTER	240010
MOORES COMPREHENSIVE CANCER CENTER	050025
NORRIS COTTON CANCER CENTER	300003
ROBERT H. LURIE COMPREHENSIVE CANCER CENTER	140281
RUTGERS CANCER INSTITUTE OF NEW JERSEY	310038
SIDNEY KIMMEL COMPREHENSIVE CANCER CENTER	210009
ST. JUDE CHILDREN'S RESEARCH HOSPITAL	443302
UAB COMPREHENSIVE CANCER CENTER	010033
UC DAVIS COMPREHENSIVE CANCER CENTER	050599
UCSF HELEN DILLER FAMILY COMPREHENSIVE CANCER CENTER	050454
UNC LINEBERGER COMPREHENSIVE CANCER CENTER	340061
UNIVERSITY OF CHICAGO COMPREHENSIVE CANCER CENTER	140088
UNIVERSITY OF COLORADO CANCER CENTER	060024
UNIVERSITY OF MICHIGAN COMPREHENSIVE CANCER CENTER	230046
UNIVERSITY OF NEW MEXICO CANCER RESEARCH & TREATMENT CENTER	320001
UNIVERSITY OF PITTSBURGH CANCER INSTITUTE	390055
UNIVERSITY OF WISCONSIN CARBONE CANCER CENTER	520098
VANDERBILT-INGRAM CANCER CENTER	440039
WAKE FOREST COMPREHENSIVE CANCER CENTER	340047
YALE CANCER CENTER	070022

3M® CRG Treatment Level

The 3M® Core Grouping software was used to stratify patients from the various cancer types and care settings into specific clinical risk groups (CRGs) based on claims spanning the period of 3 months prior to the initiating chemotherapy claim to 3 months after the initiating chemotherapy claim. Note that there are important limitations inherent in the CRG methodology. We could stratify patients only on claims information available in the Medicare 100% sample; the methodology does not take into account important clinical information (such as cancer staging) that is not available in claims data. Additionally, we are missing information that may be available on physician claims, which are only available in the Medicare 5% sample.

While technically possible to identify episodes of care for patients receiving treatment in a physician office using the Medicare 5% sample, the resulting distribution of CRGs would not be directly comparable to populations from the Medicare 100% sample due to the presence of physician claims in the Medicare 5% sample episodes and the absence of such claims in the Medicare 100% sample episodes

The adjusted prospective CRG was used in this analysis and was assigned based on claims found in the 100% Sample. Patients were included in the study if they were assigned to an actively treated CRG that corresponded to their cancer of diagnosis. The specific CRGs are listed in Table 5 below.

TABLE 5: UNDER ACTIVE TREATMENT ADJUSTED PROSPECTIVE CRGS

CANCER TYPE	ADJUSTED PROSPECTIVE CRG	CRG TREATMENT LEVEL	DESCRIPTION
BREAST	86621	1	BREAST MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 1
	86622	2	BREAST MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 2
	86623	3	BREAST MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 3
	86624	4	BREAST MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 4
COLON	86571	1	COLON MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 1
	86572	2	COLON MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 2
	86573	3	COLON MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 3
	86574	4	COLON MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 4
LUNG	86471	1	LUNG MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 1
	86472	2	LUNG MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 2
	86473	3	LUNG MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 3
	86474	4	LUNG MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 4
OVARIAN	86501	1	OVARIAN MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 1
	86502	2	OVARIAN MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 2
	86503	3	OVARIAN MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 3
	86504	4	OVARIAN MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 4
PANCREATIC	86481	1	PANCREATIC MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 1
	86482	2	PANCREATIC MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 2
	86483	3	PANCREATIC MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 3
	86484	4	PANCREATIC MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 4
PROSTATE	86631	1	PROSTATE MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 1
	86632	2	PROSTATE MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 2
	86633	3	PROSTATE MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 3
	86634	4	PROSTATE MALIGNANCY – UNDER ACTIVE TREATMENT LEVEL – 4

Table 6 below shows patient counts at various points in the patient screening process. The final study population is 46,272 patients.

TABLE 6: STUDY POPULATION WATERFALL ANALYSIS

DATA SCREEN	PATIENT COUNT
PATIENTS ACTIVELY TREATED WITH CHEMOTHERAPY INFUSIONS[1]	209,216
PATIENTS DIAGNOSED WITH A CANCER OF INTEREST[2]	112,434
PATIENTS PASSING ELIGIBILITY REQUIREMENTS[3]	74,199
PATIENTS WITH 50% OR MORE OF THEIR CHEMOTHERAPY TREATMENT OCCURRING IN A SITE OF CARE COHORT	74,156

PATIENTS ASSIGNED TO AN ACTIVE TREATMENT 3M® CRG	46,272

[1]Patients reporting two chemotherapy infusion claims within 6 months of each other and a 12 month clean period of no chemotherapy prior to the initiating chemotherapy claim.

[2]Cancers of interest include breast, colon, lung, ovarian, pancreatic, and prostate cancer.

[3]ESRD patients were excluded from the analysis. Patients were also required to have continuous, Part A and B, non-HMO coverage beginning 12 months prior to the initiating chemotherapy claim through the date of death or 36 months (whichever comes first).

The baseline patient demographic characteristics were compared by Pearson chi-squared tests. Age at diagnosis was categorized by generating quartiles based on the distribution within the study cohort.

TABLE 7: BASELINE DEMOGRAPHICS OF THE STUDY POPULATION

	PPS-EXEMPT		TEACHING HOSPITAL		NCI		OTHER HOSPITAL		TOTAL		
	N	%	N	%	N	%	N	%	N	%	*P*[1]
TOTAL	4,133	100%	21,687	100%	3,806	100%	16,646	100%	46,272	100%	-
CANCER TYPE											
BREAST	904	22%	4,712	22%	752	20%	3,602	22%	9,970	22%	<.0001
COLON	512	12%	2,707	12%	318	8%	2,342	14%	5,879	13%	
LUNG	1,462	35%	8,555	39%	1,281	34%	7,241	44%	18,539	40%	
OVARIAN	456	11%	2,611	12%	629	17%	1,260	8%	4,956	11%	
PANCREATIC	665	16%	2,285	11%	659	17%	1,494	9%	5,103	11%	
PROSTATE	134	3%	817	4%	167	4%	707	4%	1,825	4%	
CRG TREATMENT LEVEL											
1	443	11%	3,592	17%	659	17%	2,599	16%	7,293	16%	<.0001
2	1,072	26%	5,932	27%	917	24%	4,738	28%	12,659	27%	
3	1,883	46%	7,756	36%	1,502	39%	6,054	36%	17,195	37%	
4	735	18%	4,407	20%	728	19%	3,255	20%	9,125	20%	
GENDER											
MALE	1,444	35%	8,012	37%	1,330	35%	6,690	40%	17,476	38%	<.0001
FEMALE	2,689	65%	13,675	63%	2,476	65%	9,956	60%	28,796	62%	
DUAL STATUS[2]											
NO	3,592	87%	17,620	81%	3,252	85%	13,624	82%	38,088	82%	<.0001
YES	541	13%	4,067	19%	554	15%	3,022	18%	8,184	18%	
AGE AT DIAGNOSIS											
<67	852	21%	5,348	25%	880	23%	3,914	24%	10,994	24%	<.0001
67-71	1,131	27%	5,163	24%	986	26%	3,991	24%	11,271	24%	
71-76	1,113	27%	5,402	25%	982	26%	4,147	25%	11,644	25%	
76+	1,037	25%	5,774	27%	958	25%	4,594	28%	12,363	27%	
DIED	2,619	63%	14,327	66%	2,557	67%	11,363	68%	30,866	67%	<.0001

[1]P-value from Chi-Squared test which tests if the proportion of patients from each care setting are different from each other. A value <0.05 is considered significant to disprove the null hypothesis; the null hypothesis is that the proportions are not different.

[2]Patients eligible for Medicaid benefits as well as Medicare Part A and Part B.

2016 Nationwide Cost Development

Allowed amounts were repriced to the Medicare 2016 fee schedule and adjusted to a nationwide basis using the *Milliman Medicare Repricer*. Due to certain limitations with the repricer, other methods were used to remove the effect of wage index adjustments and trend dollars to 2016 for claims not adjusted by the repricer.

- Inpatient - The provider wage index was adjusted to account for labor share and removed from the allowed amount. In addition, capital amounts were adjusted separately using the capital geographic adjustment factor corresponding to the provider CBSA. Adjusted allowed amounts were then trended to 2016 using market basket updates published by CMS.
- Outpatient - The provider wage index was adjusted to account for the labor share and removed from the allowed amount. This amount was then trended to 2016 using market basket updates published by CMS. For claims where a provider wage index was not available, the rural CBSA wage index associated with the first two digits of the CCN was used.
- Home Health and Hospice - The urban CBSA wage index associated with the CCN was removed and allowed amount were trended to 2016 using market basket updates published by CMS. In the case that no urban CBSA wage index was found, the first two digits on the CCN were used to map to a rural CBSA wage index.
- Skilled Nursing Facility - The first two digits on the CCN were used to map to a rural CBSA wage index. The wage index was adjusted to account for the labor share and removed. Dollars were then trended to 2016 using market basket updates published by CMS.
- Physician - Nationwide amounts for the most prevalent HCPCS were found using the CMS physician fee schedule. For the remaining claims, the geographical adjustment factor (GAF) associated with the SSA county code of the patient's residence was removed from the allowed amount. Dollars were then trended to 2016 using the Medicare Economic Index.
- Durable Medical Equipment - Due to the complexity of nationwide DME costs, the only adjustment made to these claims was trending the original allowed amounts to 2016 using the Medicare Economic Index.

Development of Multivariate Cox Proportional Hazard Models

The primary outcome of this study was overall survival. Overall survival was defined as the time from the initial episode start date to date of death. Patients who were still alive at 36 months were censored. Cox proportional-hazard regression models were constructed to examine differences in mortality among provider types. Departures from the proportional hazards assumption were assessed based on examination of the Schoenfeld residuals.[25] Multivariate cox proportional hazard models were constructed for all cancers (combined) and for each cancer site separately. For all cancers, covariates in the model included CRG treatment level, sex, dual flag status, age, and cancer site. For models for individual cancers, covariates in the models include CRG treatment level, sex (where applicable), dual flag status, and age. In all models, indicator variables were created for all categories of each covariate to allow for statistical adjustment. Statistical significance was set at two-sided $P < 0.05$. For visualization purposes, the adjusted effects of provider type on mortality were displayed using forest plots. Analyses were carried out using SAS® Version 9.4 (Cary, NC, USA).

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