Total Cost of Cancer Care by Site of Service: Physician Office vs Outpatient Hospital

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Executive Summary

Avalere Health analyzed three years of commercial health plan data to examine the differences in the total cost of care for cancer patients based on the site of service of chemotherapy or radiation therapy. Our study compared the average total episode costs for patients receiving treatment for cancer in a physician's office (including freestanding radiation therapy centers) versus those receiving treatment in a hospital outpatient department (HOPD). The total episode costs included both plan payments and patient liability (copays / co-insurance) for all services received during the treatment episode, whether related or unrelated to the care for the patient's cancer. We controlled for patient's age, gender, and the prior history of cancer in calculating the total episode costs.

Our risk-adjusted results suggest that treatment for patients receiving chemotherapy in a HOPD costs on average 24 percent more than treatment received in a physician's office. We also found care for patients treated in a physician's office less expensive regardless of the length of the chemotherapy duration. The average chemotherapy episode lasted 3.8 months for patients managed in a physician's office versus 3.4 months for patients managed in a HOPD. For chemotherapy lasting only one month, patients treated in a hospital outpatient setting cost 28 percent more than patients managed in a physician's office. For patients receiving a full 12 months of chemotherapy, hospital outpatient care costs 53 percent more than in the physician office-based setting.

For patients receiving radiation therapy, approximately two-thirds of the treatment episodes lasted one or two months and cost approximately 15 percent and 4 percent more, respectively, in a HOPD versus a freestanding location. Approximately one-third of treatment episodes lasted three months and were about 8 percent more expensive in a freestanding location versus the hospital outpatient setting. The average radiation therapy episode lasted 2.1 months for patients managed in a freestanding location versus 1.9 months for patients managed in a HOPD.

There are many possible reasons for the differences in episode costs, including some that we investigate in this paper and many that we cannot investigate. In particular, there may be patient acuity factors, which we cannot measure that necessitate higher spending in one setting versus the other. As such, our results should be interpreted with caution, as shifts in the setting of care may not result in the magnitude of savings suggested by these results.

* * * * * *

Avalere Health was commissioned by the Community Oncology Alliance to analyze data provided by health plan members of the National Association of Managed Care Physicians (NAMCP) Medical Directors Institute. The claims data analyzed for this paper are from four large commercial managed care plans, covering an estimated 9 million individuals. The Community Oncology Alliance received funding from Amgen and Millennium Pharmaceuticals for this study. The analysis, findings, and discussion sections of this paper represent the independent work of Avalere Health.

Chemotherapy Analysis

Characteristics of Chemotherapy Treatment Episodes

Our chemotherapy analysis focused on patients who received all of their chemotherapy during a single episode in either: a physician's office (referred to as "office-managed" for the remainder of this document); or a hospital outpatient department (HOPD) (referred to as "HOPD-managed" for the remainder of this document). After exclusions, we analyzed 26,168 episodes for 22,204 individual patients, representing an average of 1.2 episodes per patient in the analysis. Seventy-five percent of the chemotherapy episodes were office-managed, with the remaining 25 percent of the episodes being HOPD-managed. (See Appendix I for a full description of our methodology)

Table 1: Distribution of Chemotherapy Patients and Episodes by Setting of Therapy

	Total	Office-managed	HOPD-managed
Patients in analysis*	22,204	16,675	5,656
Episodes in analysis	26,168	19,562	6,606
Percent of total episodes		75%	25%
Average number of episodes per patient	1.2	1.2	1.2

Source: Avalere Health analysis of NAMCP member data
* Some patients received separate episodes in different settings

Eighty-eight percent of all episodes analyzed were for patients aged 60 and older. There appears to be a relationship between age and setting for chemotherapy episodes, as older patients were more likely than younger patients to be office-managed. About 69 percent of episodes for patients 49 years old or younger were office-managed compared to over 87 percent of episodes for patients 90 years old or older.

Figure 1: Age Distribution of All Chemotherapy Episodes

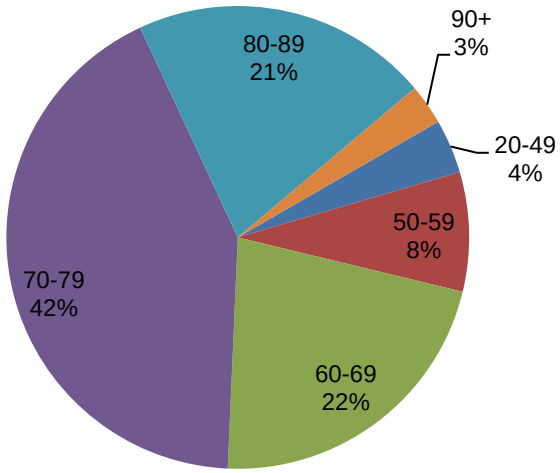
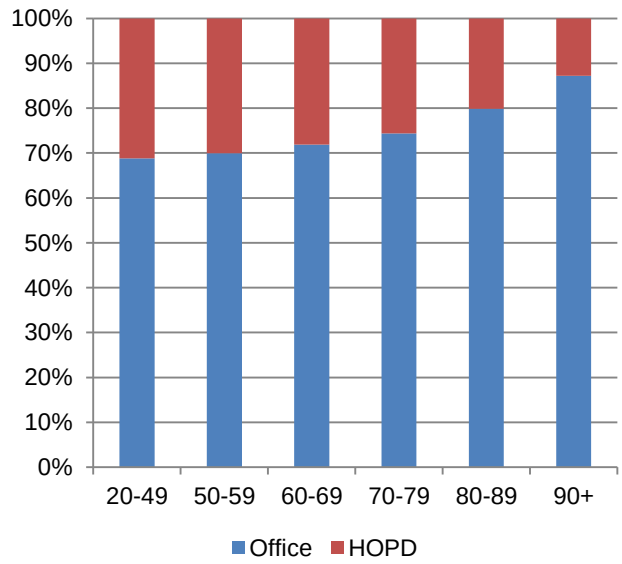


Figure 2: Percent of Chemotherapy Episodes Office-managed versus HOPD-managed, by Age Group



Source: Avalere Health analysis of NAMCP member data

More males than females received chemotherapy in our study (56 percent versus 44 percent). Both genders received mainly office-managed therapy; however, males were more likely to be office-managed than females. Over 78 percent of episodes for men were office-managed, compared to 70 percent of episodes for women.

Figure 3: Gender Distribution of All Chemotherapy Episodes

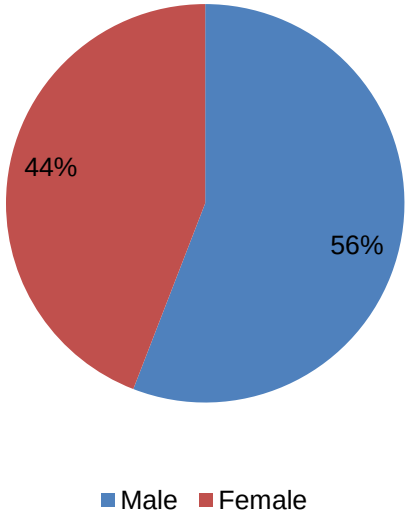
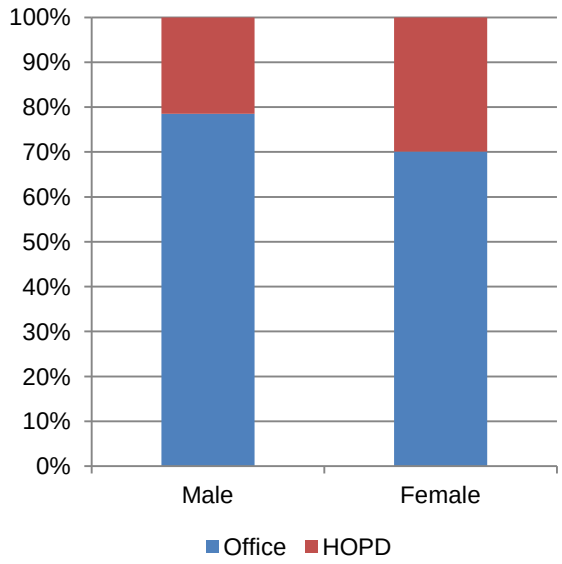


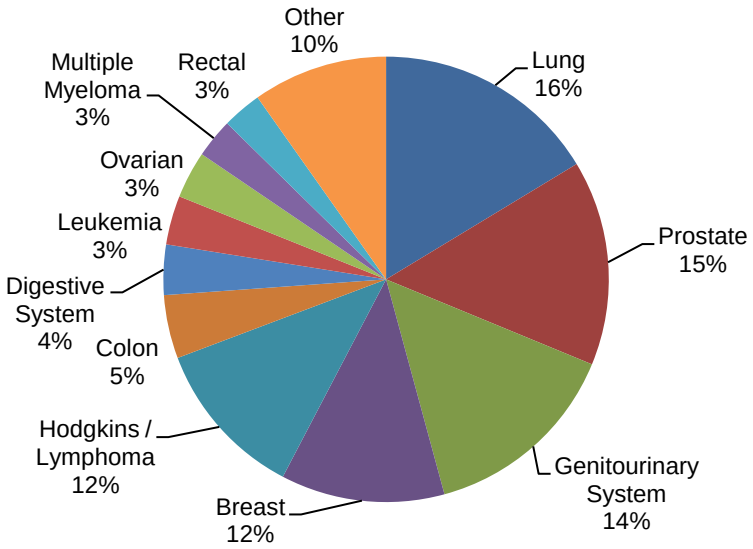
Figure 4: Percent of Chemotherapy Episodes Office-managed versus HOPD-managed, by Gender



Source: Avalere Health analysis of NAMCP member data

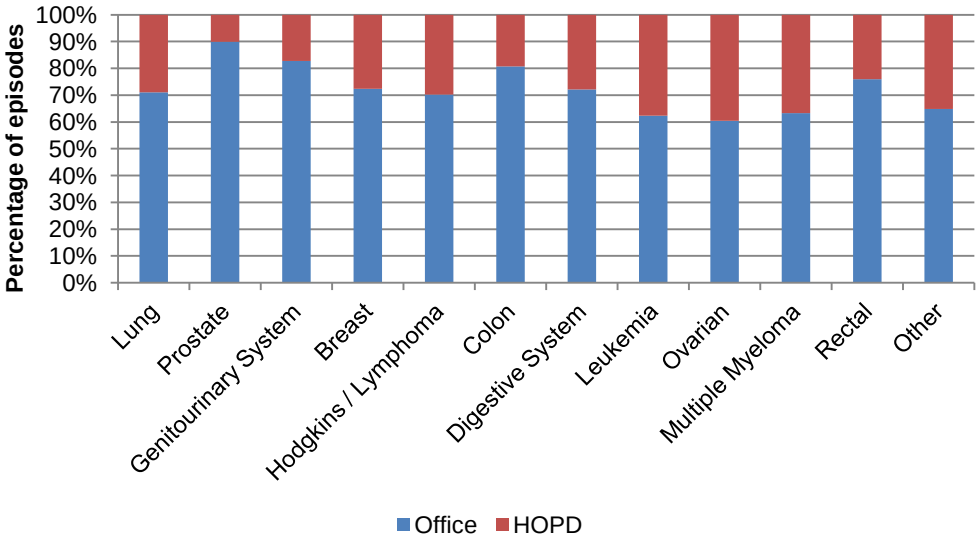
Eleven types of cancer accounted for over 90 percent of all chemotherapy episodes, including six cancers that accounted for nearly 75 percent of all episodes. Although office-managed therapy is dominant across all cancer categories, the distribution of office-managed episodes varies across different cancers. For example, 90 percent of chemotherapy to treat prostate cancer was office-managed verus 61 percent of chemotherapy to treat ovarian cancer.

Figure 5: Cancer Distribution of All Chemotherapy Episodes



Source: Avalere Health analysis of NAMCP member data

Figure 6: Percent of Chemotherapy Episodes Office-managed versus HOPD-managed, by Type of Cancer



Source: Avalere Health analysis of NAMCP member data

Cost of Care for Chemotherapy Patients

On an unadjusted basis, we found the average cost of care per episode for office-managed chemotherapy was about $19,640, while the average cost of care per episode for HOPD-managed chemotherapy was $26,300, a 34 percent difference. The lower cost for office-managed patients persists despite a longer average length for office-managed episodes: the average office-managed chemotherapy episode lasted 3.8 months versus 3.4 months for HOPD-managed patients. These costs are for all care provided to patients receiving chemotherapy, and may include costs unrelated to the cancer treatment. (See Appendix I for a full description of the methodology used in the analysis).

Office-managed chemotherapy episodes had lower costs regardless of the length of the episode. For episodes lasting one month or less, office-managed chemotherapy had an average cost of $7,350 per episode, while HOPD-managed chemotherapy had an average cost of $9,903 per episode, a nearly 35 percent difference. The largest difference was for patients with episodes of nine months: office-managed patients had an average cost of nearly $26,800, while HOPD-managed patients had an average cost of nearly $57,400, a difference of over 114 percent.

Table 2: Unadjusted Chemotherapy Episode Costs, by Length of Episode

	Office-managed episodes		HOPD-managed episodes		
Length of episode in months	Number of episodes	Average episode cost	Number of episodes	Average episode cost	Percent difference
1	4,601	$7,350	1,784	$9,903	34.7%
2	3,679	$11,937	1,240	$17,517	46.7%
3	2,502	$19,238	1,091	$24,592	27.8%
4	2,518	$23,960	859	$32,251	34.6%
5	1,601	$26,979	481	$40,677	50.8%
6	1,151	$35,656	332	$47,824	34.1%
7	1,091	$26,395	268	$40,879	54.9%
8	635	$33,233	165	$56,493	70.0%
9	734	$26,794	127	$57,384	114.2%
10	445	$35,620	105	$47,870	34.4%
11	302	$47,468	69	$63,366	33.5%
12	303	$46,338	85	$87,242	88.3%

Source: Avalere Health analysis of NAMCP member data
Costs include all care received by patient during chemotherapy episode, including some care unrelated to the provision of chemotherapy

To test the impact of certain beneficiary characteristics, we applied a basic risk adjustment model that controlled for age, sex, and prior history of cancer (see Appendix III for a description of the risk adjustment model). After controlling for these factors, there was a slightly smaller percentage difference between the two settings, with the HOPD remaining most costly. After adjustment, the average cost of an office-managed episode was nearly $28,200 while the average cost of a HOPD-managed episode was nearly $35,000, more than a 24 percent difference. Similar to the unadjusted numbers, HOPD-managed episodes were more costly regardless of the length of the chemotherapy episode.

Table 3: Adjusted Chemotherapy Episode Costs, by Length of Episode

	Office-managed episodes		HOPD-managed episodes		
Length of episode in months	Number of episodes	Average episode cost	Number of episodes	Average episode cost	Percent difference
1	4,601	$10,764	1,784	$13,828	28.5%
2	3,679	$17,431	1,240	$23,917	37.2%
3	2,502	$26,893	1,091	$32,541	21.0%
4	2,518	$33,192	859	$42,628	28.4%
5	1,601	$39,220	481	$53,538	36.5%
6	1,151	$49,062	332	$61,661	25.7%
7	1,091	$39,888	268	$55,216	38.4%
8	635	$47,709	165	$74,066	55.2%
9	734	$42,838	127	$75,645	76.6%
10	445	$48,683	105	$67,003	37.6%
11	302	$67,068	69	$86,938	29.6%
12	303	$66,826	85	$102,395	53.2%

Source: Avalere Health analysis of NAMCP member data
Cost estimates adjusted for age, sex, and prior history of cancer
Costs include all care received by patient during chemotherapy episode, including some care unrelated to the provision of chemotherapy

While our risk adjustment model adjusts for certain factors such as age, sex, and prior history of cancer, it cannot control for other factors that may influence total cost of care such as mortality, morbidity, or other factors, many of which are not analyzable in our administrative claims-based dataset. We also have not controlled for the type of chemotherapeutic agent used during the episode, largely for reasons discussed below. Therefore, we encourage the reader to interpret these cost differences with caution.

Cancer-specific Chemotherapy Results

The average episode costs vary widely based on the type of cancer. Below we compare the average episode costs for the eight most prevalent cancer types for patients in these plans, which account for over 80 percent of all episodes in the sample.

Table 4: Average Adjusted Episode Costs for Eight Most Common Cancers

	Office-managed episodes		HOPD-managed episodes		
Type of cancer	Number of episodes	Average episode cost	Number of episodes	Average episode cost	Percent difference
Lung	3,036	$32,913	1,239	$32,382	-1.6%
Prostate	3,503	$21,299	394	$25,504	19.7%
Genitourinary System	3,152	$8,960	655	$19,592	118.7%
Breast	2,252	$30,072	860	$33,391	11.0%
Hodgkin's / Lymphoma	2,131	$39,080	902	$42,537	8.8%
Colon	973	$45,997	233	$46,220	0.5%
Digestive System	688	$30,018	266	$30,044	0.1%
Leukemia	581	$39,008	350	$43,508	11.5%
Any	19,562	$28,177	6,606	$34,973	24.1%

Source: Avalere Health analysis of NAMCP member data
Cost estimates adjusted for age, sex, and prior history of cancer
Costs include all care received by patient during chemotherapy episode, including some care unrelated to the provision of chemotherapy

Chemotherapy Discussion

Chemotherapy patients of the health plans analyzed predominantly receive office-managed care. The analysis of average episode costs suggests that the total cost of care is lower for office-managed chemotherapy episodes compared to HOPD-managed episodes. While there are many possible reasons for the differences in these costs, we tested two specific hypotheses: hospitalizations and billing practices.

One possible explanation for the cost difference between the settings could be related to inpatient hospitalizations. We examined the hospitalization rate for patients during the chemotherapy episode. On average, 14 out of every 100 HOPD-managed episodes had at least one hospitalization during the episode, while only 11 out of every 100 office-managed episodes had at least one hospitalization. Some of the increased costs of HOPD-managed episodes can be attributed to the higher rate of hospitalization.

Another possible explanation for the cost difference could be related to hospital and physician office billing practices. The amount of information submitted by providers regarding the nature of treatment varies widely. Specific to chemotherapy, providers could be submitting a claim for a specific chemotherapeutic agent by using the associated Healthcare Common Procedure Coding System (HCPCS) J-code. Alternately, some providers may only submit a Uniform Billing (UB-04) revenue code to indicate the administration of chemotherapy. In many cases, a plan may have a specific reimbursement rate for each J-code, whereas a plan may reimburse a

revenue code-based claim at a discount of submitted charges. Note, physician offices cannot submit a revenue code on the standard CMS-1500 physician claim form, although some physicians may have alternate arrangements with specific payers.

In our dataset, 66 percent of the HOPD-managed episodes submitted claims using a revenue code for chemotherapy rather than a J-code. We found that the revenue code HOPD-managed episodes tended to have higher costs than J-code HOPD-managed episodes and all office-managed episodes.

Table 5: Average Adjusted Episode Cost by Site of Service and Type of Chemotherapy Claim

Category	Percent of episodes	Average cost of episode
HOPD – revenue code	66%	$36,227
HOPD – J-code	33%	$32,541
Office – J-code	98%	$28,160

Source: Avalere Health analysis of NAMCP member data
Episodes that had only NDC codes for chemotherapy agents not included in this table

As discussed above, there are many other possible explanations for the differences in episode costs, including utilization patterns, other patient acuity factors, stage of cancer, mortality, etc. Unfortunately, we are not able to analyze many of these issues using administrative claims.

Chemotherapy Summary

Our analysis found that patients receiving HOPD-managed chemotherapy have average adjusted costs per episode that are anywhere between 20-80 percent higher than for office-managed chemotherapy. The average cost differences vary widely based on type of cancer. We note these results are similar to a recent analysis comparing costs of chemotherapy care for Medicare fee-for-service patients.[1]

Across all plans in the sample, the total unadjusted cost of care for all patients who received chemotherapy between 2008 and 2010 was nearly $558 million, including $384 million spent on office-managed episodes and $174 million on HOPD-managed episodes. While we acknowledge there are many confounding factors between the two patient samples, if the HOPD-managed episodes had cost the same per episode as the office-managed episodes, the total cost of care could have been reduced by over $43 million over the three-year period, or 8 percent.

[1] Fitch, Kate and Bruce Pyenson. *Site of Service Cost Differences for Medicare Patients Receiving Chemotherapy*. Milliman, Inc, NY. October 19, 2011.

Radiation Therapy Analysis

Characteristics of the Radiation Therapy Treatment Episodes

Our radiation therapy analysis focuses on patients who received all of their radiation therapy for a single episode in either a freestanding radiation therapy center (office-managed) or hospital outpatient department (HOPD-managed). After exclusions, we analyzed 19,725 episodes for 19,025 patients, representing an average of 1.0 episodes per patient in the analysis. Fifty-one percent of the episodes were office-managed, and 49 percent were HOPD-managed.

Table 6: Distribution of Radiation Therapy Patients and Episodes by Setting of Care

	Total	Office-managed	HOPD-managed
Patients in analysis *	19,025	9,747	9,315
Episodes in analysis	19,725	10,121	9,604
Percent of total episodes		51%	49%
Average number of episodes per patient	1.0	1.0	1.0

Source: Avalere Health analysis of NAMCP member data

Eighty-nine percent of all radiation therapy episodes in this analysis were for patients aged 60 and older. The distribution of episodes by setting of care indicates that older patients are more likely to receive office-managed radiation therapy as opposed to HOPD-managed therapy. About 43 percent of episodes for patients 49 years old or younger were office-managed compared to 54 percent of episodes for patients 90 years old or older.

Figure 7: Gender Distribution of All Radiation Therapy Episodes

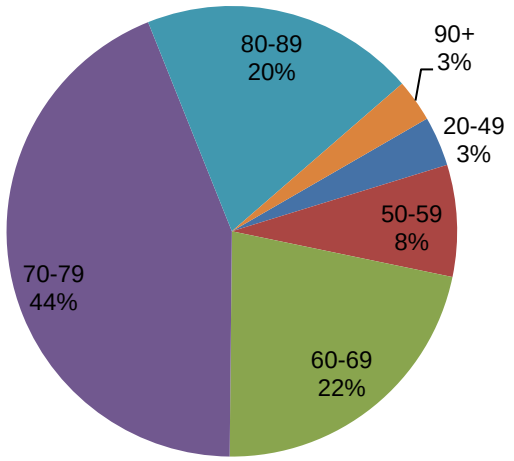
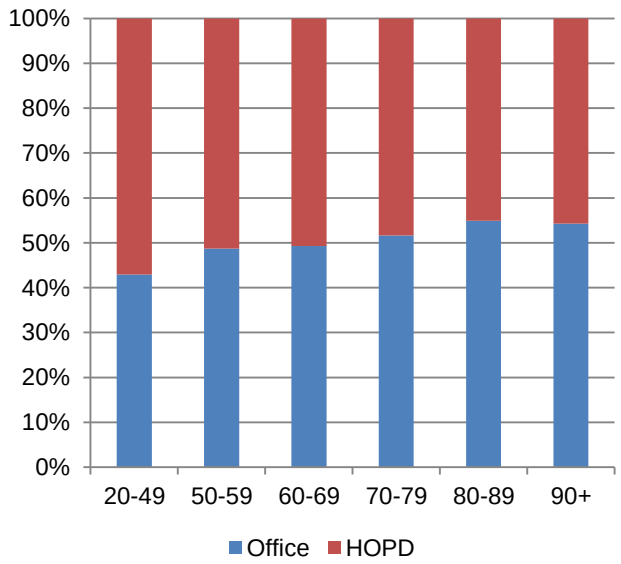


Figure 8: Percent of Radiation Therapy Episodes Office-managed versus HOPD-managed, by Age Group



Source: Avalere Health analysis of NAMCP member data

Slightly more males than females received radiation therapy in our study (51 percent versus 49 percent). Men were also slightly more likely to receive office-managed radiation therapy (54 percent of episodes) than females (49 percent of episodes).

Figure 9: Gender Distribution of All Radiation Therapy Episodes

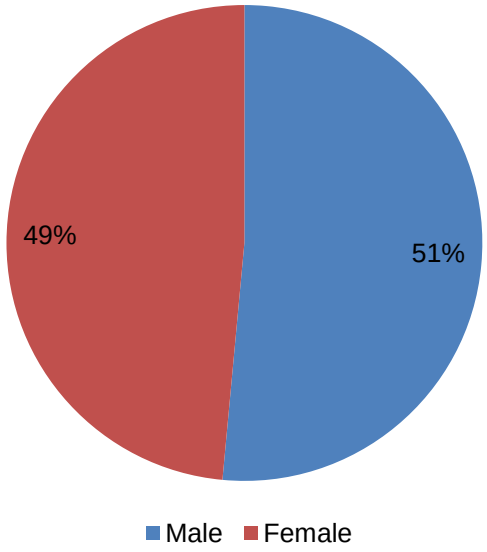
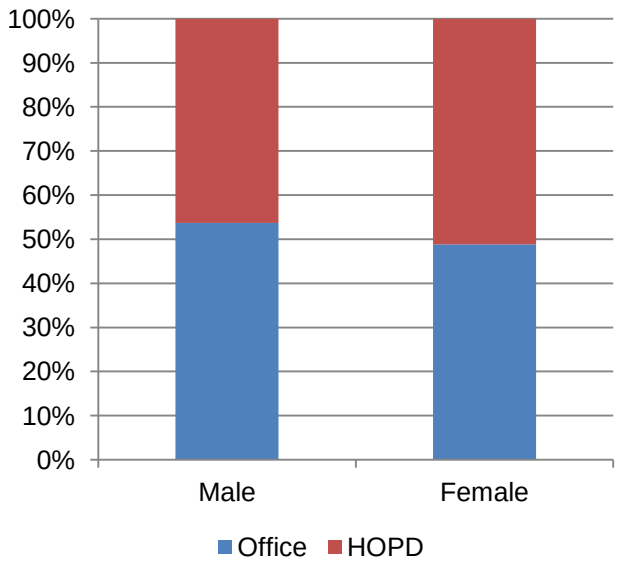


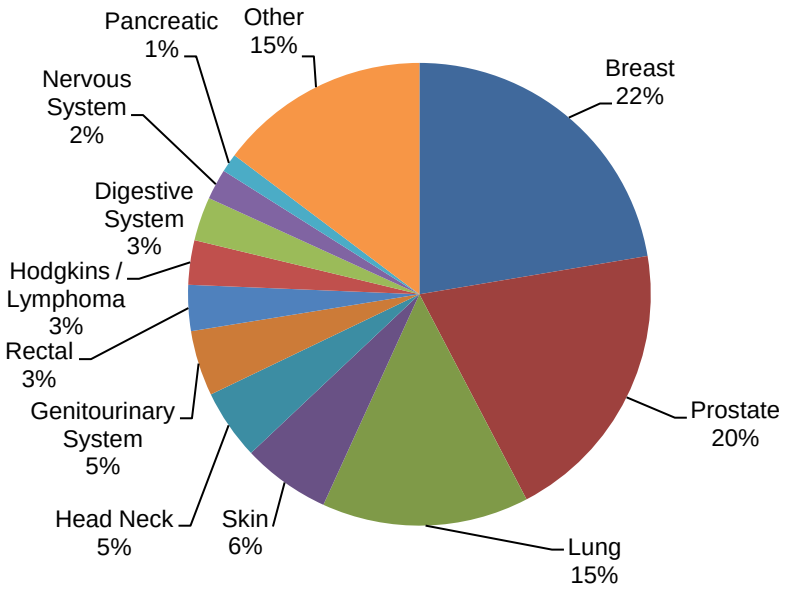
Figure 10: Percent of Radiation Therapy Episodes Office-managed versus HOPD-managed, by Gender



Source: Avalere Health analysis of NAMCP member data

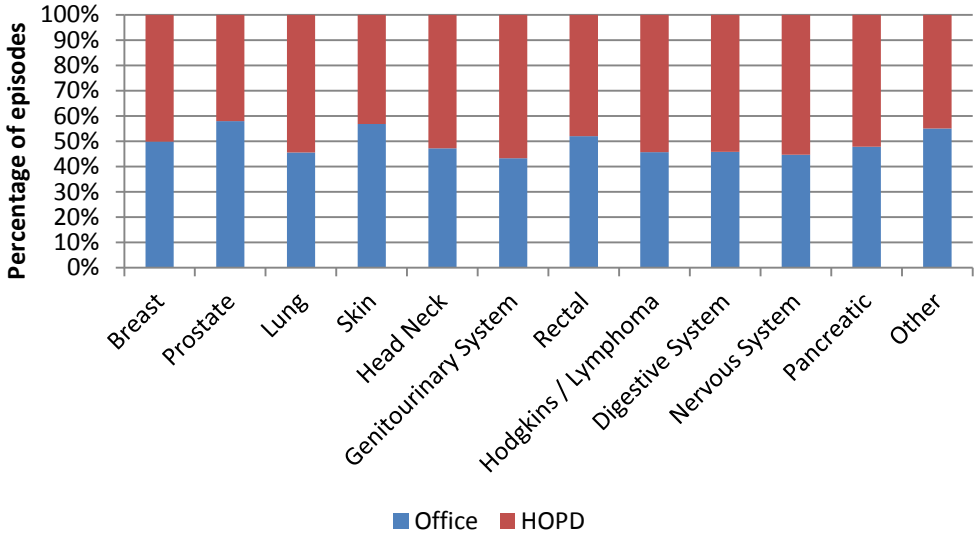
Eleven types of cancer accounted for 85 percent of all radiation therapy episodes, including six cancers that accounted for over 70 percent of the episodes. The episode distribution between settings of care varies across different cancer categories. For example, 58 percent of prostate cancer radiation therapy episodes were office-managed, whereas 43 percent of genitourinary system cancer radiation therapy episodes were office-managed.

Figure 11: Cancer Distribution of All Radiation Therapy Episodes



Source: Avalere Health analysis of NAMCP member data

Figure 12: Percent of Radiation Therapy Episodes Office-managed versus HOPD-managed, by Type of Cancer



Source: Avalere Health analysis of NAMCP member data

Costs of Care for Radiation Therapy Patients

On an unadjusted basis, we found the average cost of an office-managed radiation therapy episode was about $16,300, while the average cost of a HOPD-managed radiation therapy episode was $16,000, a 2 percent difference. The average radiation therapy episode lasted 2.1 months for office-managed patients versus 1.9 months for HOPD-managed patients.

Interestingly, HOPD-managed radiation therapy episodes of one or two months were between 7 and 17 percent more expensive than similar-length office-managed episodes, while HOPD-managed episodes of three months were 4 percent less expensive.

Table 7: Unadjusted Radiation Therapy Episode Costs by Length of Episode

	Office-managed episodes		HOPD-managed episodes		
Length of episode in months	Number of episodes	Average episode cost	Number of episodes	Average episode cost	Percent difference
1	2,736	$7,345	2,905	$8,569	16.7%
2	4,080	$15,303	4,288	$16,444	7.5%
3	3,305	$25,053	2,411	$24,022	-4.1%

Source: Avalere Health analysis of NAMCP member data
Costs include all care received by patient during chemotherapy episode, including some care unrelated to the provision of radiation therapy

We tested the impact of certain beneficiary characteristics via a basic risk adjustment model that controlled for age, sex, and prior history of cancer. After controlling for these factors, office-managed episodes remained more expensive than HOPD-managed episodes overall, although shorter episodes were less expensive when office-managed. After adjustment, the average cost of an office-managed episode was about $25,100, while the average cost of a HOPD-managed episode was $23,800, a difference of 6 percent. Similar to unadjusted numbers, radiation therapy episodes of one or two months were more expensive when HOPD-managed, while episodes of three months were less expensive when HOPD-managed.

Table 8: Adjusted Radiation Therapy Episode Costs by Length of Episode

	Office-managed episodes		HOPD-managed episodes		
Length of episode in months	Number of episodes	Average episode cost	Number of episodes	Average episode cost	Percent difference
1	2,736	$11,472	2,905	$13,209	15.1%
2	4,080	$23,305	4,288	$24,150	3.6%
3	3,305	$38,732	2,411	$35,761	-7.7%

Source: Avalere Health analysis of NAMCP member data
Cost estimates adjusted for age, sex, and prior history of cancer
Costs include all care received by patient during chemotherapy episode, including some care unrelated to the provision of radiation therapy

Similar to our chemotherapy analysis, our risk adjustment model adjusts for certain factors such as age, sex, and prior history of cancer. Our model cannot, however, adjust for other factors that

may influence total cost of care such as mortality, morbidity, or other factors, many of which are not analyzable in our administrative claims-based dataset. We also have not controlled for the specific radiation therapy modality used during the episode, again partly due to the lack of uniformity on billing patterns between office- and HOPD-managed episodes. Therefore, we encourage the reader to interpret these cost differences with caution.

Cancer-specific Radiation Therapy Results

The average episode costs vary widely based on the type of cancer. Below, we compare the average radiation therapy episode costs for the eight most prevalent cancer types for patients in these plans, which account for over 80 percent of all episodes in the sample.

Table 9: Average Adjusted Radiation Therapy Episode Costs for Eight Most Common Cancers

	Office-managed episodes		HOPD-managed episodes		
Type of cancer	Number of episodes	Average episode cost	Number of episodes	Average episode cost	Percent difference
Breast	2,200	$20,342	2,209	$23,792	17.0%
Prostate	2,285	$37,472	1,657	$29,800	-20.5%
Lung	1,301	$24,669	1,554	$21,867	-11.4%
Skin	691	$12,072	524	$12,839	6.4%
Head Neck	456	$35,181	511	$32,715	-7.0%
Genitourinary System	391	$23,198	511	$23,779	2.5%
Rectal	329	$28,148	304	$26,492	-5.9%
Hodgkin's / Lymphoma	280	$17,276	332	$16,135	-6.6%
Any	10,121	$25,144	9,604	$23,756	-5.5%

Source: Avalere Health analysis of NAMCP member data
Cost estimates adjusted for age, sex, and prior history of cancer
Costs include all care received by patient during chemotherapy episode, including some care unrelated to the provision of radiation therapy

Radiation Therapy Discussion

The radiation therapy episodes included in this analysis were nearly equally split between office-managed and HOPD-managed, a sign of the growing utilization of non-hospital settings for this type of therapy. Our analysis found that on average, the total cost of care for patients HOPD-managed were slightly lower than for office-managed patients.

Unlike the chemotherapy analysis, very few of the episodes in our radiation therapy analysis were identified via a revenue code. This suggests that both HOPDs and office/freestanding locations are submitting specific CPT/HCPCS codes when billing for radiation therapy patients, which may in turn partly explain the similarities in overall costs.

We also investigated the impact of hospitalizations on episode costs. The rate of hospitalization for radiation therapy patients was nearly the same in both settings: approximately nine out of every 100 office-managed radiation therapy episodes had at least one hospitalization, while 10 out of every 100 HOPD-managed radiation therapy episodes had at least one hospitalization.

As discussed above, there are many other possible explanations for the differences in episode costs, including utilization patterns, other patient acuity factors, stage of cancer, mortality, etc. In particular, there are several different modalities of radiation therapy, with substantially different payment structures, which may be influencing these results. While the rate of revenue code billing was low, it still prevents us from estimating costs based on similar modalities. In addition, choice of radiation therapy modality is often driven by numerous clinical and operational factors. Unfortunately we are not able to analyze many of these factors using administrative claims.

Radiation Therapy Summary

Our analysis found that HOPD-managed patients have slightly lower episode costs compared to office-managed patients. After risk adjustment, HOPD-managed patients remain less expensive overall than office-managed patients. However, this difference is entirely due to episodes that last three months, as episodes of one or two months were more expensive when managed in the HOPD.

Across all plans in the sample, the total unadjusted cost of care for patients who received radiation therapy between 2008 and 2010 was over $318 million, including $165 million for office-managed episodes and $153 million for HOPD-managed episodes. Acknowledging the confounding factors between the two patient samples, if HOPD-managed episodes had cost the same per episode as office-managed episodes, the total cost of care would have been reduced by approximately $1 million, or less than 1 percent. These savings largely arise from the lower costs in the first two months of radiation therapy when office-managed treatment costs less than HOPD-managed treatment.

Appendix I: Methodology

Avalere analyzed claims data provided by four commercial health insurance carriers for paid medical and pharmaceutical services rendered between January 1, 2008, and December 31, 2010, to patients with diagnosed with any type of cancer. Each contributing plan provided all inpatient, outpatient, physician office, and pharmacy paid claims for any patient who had a diagnosis of any cancer during the three-year period.

To control for the potential of patients changing plans, we required all patients in the analysis to be enrolled with the plan for at least six months prior to the initiation of chemotherapy or radiation therapy. We excluded any patient under the age of 20, as pediatric and teenage cancer patients tend to have significantly higher costs. We also excluded any patient who received a transplant at any point during the three-year period. Finally, we limited our analysis to patients who received 12 or fewer months of chemotherapy or three or fewer months of radiation therapy.

Identification of Therapy and Cancer Type

We identified all instances of a patient receiving chemotherapy or radiation therapy during the three-year period. Chemotherapy was identified via a J-code or NDC for a chemotherapy drug or UB-04 revenue code for chemotherapy administration. Radiation therapy was identified via a CPT code for radiation therapy or UB-04 revenue code for radiation treatment.

We identified the treatment-specific cancer based on the ICD-9-CM[2] diagnosis code located on the chemotherapy or radiation therapy claim. We grouped cancer diagnosis codes into 28 broad cancer categories. We excluded patients from the study for whom we were unable to locate a cancer diagnosis on any chemotherapy or radiation therapy claim. We also excluded patients who had only one chemotherapy or radiation therapy claim indentified in the dataset.

Creation of Treatment Episodes

We created treatment episodes based on service dates of the chemotherapy or radiation therapy. We identified the start of an episode as the service date of the first therapy and defined the end of the episode as the last identified therapy. We identified the end of an episode as a lapse of therapy for at least 60 days.

In most cases, episodes only had treatment for a single cancer category. In instances where episodes had multiple cancers listed on the therapy claims, we assigned the episode to a specific cancer category if at least 60 percent of the chemotherapy or radiation therapy claims were for only one cancer category. If the episode did not meet this criterion, it was excluded from the analysis.

We divided all treatment episodes into office-managed and hospital outpatient department (HOPD)-managed using the place of service codes from chemotherapy or radiation therapy

[2] ICD-9-CM: international classification of diseases, 9th revision; clinical modification, 6th edition, 2006 / Practice Management Information Corporation (PMIC). Published Los Angeles, CA : PMIC, C2005.

claims to identify the setting of care. An episode needed to have all of the chemotherapy or radiation therapy claims in one setting to qualify for the assignment of that setting.

Costs of Care Measurement

To create the episode costs by month, we measured costs of all medical and pharmacy services in 30-day increments after initiation of each episode. To remove the influence of plan benefit design, we included plan paid amounts and patient liability (copay/coinsurance and deductibles) when measuring total costs. We did not include any costs incurred after the end of our defined episode.

To reduce the impact of high or low cost outlier episodes, we calculated the log of each episode's average cost and removed any episode that was above or below two standard deviations from the mean.

Risk Adjustment

We tested an adjusted episode cost analysis to determine if there were any factors that contributed to cost differences. Specifically, we tested two separate risk-adjustment regression models. The first model controlled for age, sex, prior history of cancer, and type of cancer. The second model controlled for age, sex, and prior history of cancer. (Note, only the results of the second model are presented in the paper).

We identified any prior history of cancer before the start of each patient's episode. Prior history of cancer was defined as a presence of at least one of the following:

- Previous cancer therapy episode for the same patient;
- Outpatient claim for a different therapy at least 30 days before the start of the episode;
- Inpatient claim with the same cancer diagnosis at least 30 days before the start of the episode;
- One inpatient claim or two outpatient claims with different cancer diagnosis before the start of the episode.

The control group in the model we used consisted of treatment episodes for females, less than 50 years old, with no prior history of cancer.

Appendix II: Codes Used for Analyses

Table 10: Codes used for Identifying Chemotherapy or Radiation Therapy

Chemotherapy	Radiation therapy
Included if claim includes:	**Included if claim includes:**
J8520-J9999	CPT 77261-77799
Revenue code 331, 332, or 335	Revenue code 333
CPT 96360-96549 and appropriate NDC [1]	

1 We used over 1500 separate 11-digit NDCs for chemotherapy drugs

Table 11: Cancer Definitions

Cancer group	ICD-9 code(s)
Head & Neck	141-149, 160, 161, 230.0, 231.0
Skin	140, 172, 173, 176, 232, 202.1, 238.2
Digestive System	150-152, 155, 156, 158, 159, 230.1-230.9
Colon	153
Rectal	154
Pancreatic	157
Lung	162
Respiratory System	163-166, 231.1-231.9
Bone	170, 238.0
Tissue	171, 238.1
Breast	174, 175, 233.0, 238.3
Genitourinary System	179-182, 184, 186-189, 233.1-233.3, 233.5-233.9, 236.0,
Ovarian	183, 236.2
Prostate	185, 233.4, 236.5
Eye	190
Nervous System	191, 192, 200.5, 237.5-237.9
Endocrine	193, 194, 237.0-237.4
Secondary lymph nodes	196
Secondary respiratory/digestive system	197
Secondary other	198
Hodgkin's / Lymphoma	200.0-200.4, 200.6-200.8, 201, 202.0, 202.7-202.9
Multiple Myeloma	203
Leukemia	204-208
Neuroendocrine Tumors	209
Benign Neoplasms	210-229
Bone Marrow	238.4-238.6
Neoplasms Unspecified Nature	239
Other	202.2-202.6, 203.1-203.8, 238.7-238.9, 195, 199, 234

Table 12: Transplant MS-DRGs

MS-DRG Code	MS-DRG Title
001	Heart transplant or implant of heart assist system w MCC
002	Heart transplant or implant of heart assist system w/o MCC
003	ECMO or trach w MV 96+ hrs or PDX exc face, mouth & neck w maj OR
004	Trach w MV 96+ hrs or PDX exc face, mouth & neck w/o maj OR
005	Liver transplant w MCC or intestinal transplant
006	Liver transplant w/o MCC
007	Lung transplant
008	Simultaneous pancreas/kidney transplant
009	Bone marrow transplant
010	Pancreas transplant
014	Allogeneic Bone Marrow Transplant
015	Autologous Bone Marrow Transplant
652	Kidney transplant

Appendix III: Risk Adjustment Models

We used a similar process to create risk adjustment models for chemotherapy and radiation therapy episodes. We included five age categories (20-49, 50-59, 60-69, 70-79, and 80+), gender, and prior history of cancer as independent variables in our equation, and calculated the impact of these variables on average monthly episode costs. In both models, the impact of each variable should be compared to against the excluded variable. For example, the negative coefficient in front of "age 50-59" indicates that a patient in that age category costs less than a patient between the age of 20-49.

We note that neither of the models has a very high predictive power (as measured by the Adjusted R Squared), although all of the variables are statistically significant. This suggests that while these variables do contribute to differences in episode costs, there are many other factors that result in higher or lower costs that we cannot measure via this dataset.

Chemotherapy Regression Model Results		
Adjusted R Squared	0.115	
F statistic	0.000	
Variable	***Coefficients***	***P-value***
Intercept	11,652.9	0.000
50-59	-500.6	0.000
60-69	-4,416.6	0.000
70-79	-6,434.7	0.000
80+	-7,815.2	0.000
prior_cancer_indicator	3,488.0	0.000
Male	-1,558.5	0.000

Radiation Therapy Regression Model Results		
Adjusted R Squared	0.076	
F statistic	0.000	
Variable	***Coefficients***	***P-value***
Intercept	14,721.0	0.000
50-59	-1,898.1	0.000
60-69	-5,096.8	0.000
70-79	-6,777.8	0.000
80+	-7,684.6	0.000
prior_cancer_indicator	600.6	0.000
Male	873.7	0.000