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Retrospective analysis of characteristics associated with higher-value radiotherapy episodes of care for bone metastases in Medicare fee-for-service beneficiaries

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ABSTRACT

Objectives The Centers for Medicare & Medicaid Services' newly enacted Radiation Oncology Model ('RO Model') was designed to test the cost-saving potential of prospective episode-based payments for radiation treatment for 17 cancer diagnoses by encouraging high-value care and more efficient care delivery. For bone metastases, evidence supports the use of higher-value, shorter courses of radiation (≤10 fractions). Our goal was to determine the prevalence of short radiation courses (≤10 fractions) for bone metastases and the setting, treatment and patient characteristics associated with such courses and their expenditures.

Design Using the RO Model episode file, we evaluated receipt of ≤10 fractions of radiotherapy for bone metastases and expenditures by treatment setting for Medicare fee-for-service beneficiaries during calendar years 2015–2017.
Using unadjusted and adjusted regression models, we determined predictors of receipt of ≤10 fractions and expenditures. Multivariable models adjusted for treatment and patient characteristics.

Results There were 48 810 episodes for bone metastases during the period. A majority of episodes for ≤10 fractions occurred in hospital-outpatient settings (62.8% (N=22 715)). After adjusting for treatment and patient factors, hospital-outpatient treatment setting remained a significant predictor of receiving ≤10 fractions (adjusted OR 2.03 (95% CI 1.95, 2.12; p<0.001) vs free-standing). The greatest adjusted contributors to total expenditures were number of fractions (US$−3424 (95% CI US$−3412 to US$−3435) for ≤10 fractions vs >10; p<0.001) and treatment type (including US$7716 (95% CI US$7424 to US$8018) for intensity modulated radiation therapy vs conventional external beam; p<0.001).

Conclusions A measurable performance gap exists for delivery of higher-value bone metastases radiotherapy under an episode-based model, associated with increased expenditures. The RO Model may succeed in improving the value of bone metastases radiation. Increasing the capacity of free-standing centres to implement palliative-focused services may improve the ability of these practices to succeed under the RO Model.

Strengths and limitations of this study

- ► For bone metastases, evidence supports higher-value, shorter courses of radiotherapy.
- ► The Centers for Medicare & Medicaid Services' Radiation Oncology (RO) Model may increase higher-value care for bone metastases.
- ► Evaluation of potential performance gaps in RO Model-defined bone metastases episodes help to better understand the potential for increasing value and cost-savings under the RO Model.
- ► Lack of detailed patient characteristics limits this study.

INTRODUCTION

Under current Centers for Medicare & Medicaid Services (CMS) policies, radiation therapy practices are reimbursed in large part on a fee-for-service basis per fraction of radiation delivered. CMS' established the Radiation Oncology Model[1] ('RO Model'), beginning on 1 January 2022, designed to test the cost-saving potential of prospective episode-based payments for radiation treatment for 16 cancer diagnoses to furnish more high-value, patient-centric care. CMS points to bone metastases radiotherapy data to support the rationale for the RO Model, stating that 'modifying payment under an episode payment model could change the incentives and encourage physicians to pick higher-value modalities and furnish fewer fractions, where appropriate'.[2] Substantial evidence supports the treatment of certain bone metastases with shorter treatment schedules.[3–7] Therefore, the proposed model may shift incentives in the treatment of bone metastases towards shorter (≤10 fractions) and less complex but equally efficacious[8] courses of radiation, resulting in more efficient care delivery, higher-value care and better patient outcomes.

In contrast, the most recent CMS effort to improve the value of palliative radiation for bone metastases, through the implementation of a process quality measure under the Quality Payment Programme, proved overly complex and National Quality Foundation endorsement was no longer sought.[9] The quality measure for radiation of bone metastases was felt to be too prescriptive in requiring a certain number of fractions, too complex to capture through billing and claims data, and not flexible enough to allow for changes in the plan of care which occurs frequently in patients with advanced cancer who often develop disease progression, symptom changes or enrol in hospice thus preventing further receipt of radiation.[10] Accordingly, much of the Hospital Compare data that was gathered as part of this programme are incomplete or unavailable for the measure with only of 827 (17%) of 4767 hospitals reporting. Although, in those practices who did gather Quality Payment Programme data on palliative radiation for bone metastases, the national average score for receipt of higher-quality bone metastases radiation for participating hospitals was 89% in 2018.[11]

An episode-based approach, as included in the RO Model, was developed in order to provide a more reasonable and effective approach to both measure the value and quality of care and provide an opportunity to decrease costs associated with bone metastases radiation, which we explore in this article. Specifically, we sought to determine whether available data captured in the CMS-defined 'episodes of care' included identifiable differences in the inclusion of higher-value radiotherapy for bone metastases, thus providing an opportunity for practices to increase value of care and ensure cost-savings for the programme and their practice. Furthermore, we sought to understand the specific characteristics of radiation oncology practices that could benefit from resources that aid the development of palliative radiation programmes, given that there will likely be great interest in effective ways to improve the value of radiotherapy care as the RO Model is implemented. Palliative RT programmes have been shown to nearly double the utilisation of shorter courses of radiation while maintaining patient-centred outcomes and creating substantial health-related cost savings.[12] However, such programmes are not yet commonplace in radiation oncology practices nationwide.

Therefore, the goal of this study was to evaluate CMS-defined 'episodes of care' to determine the prevalence of higher-value, guideline-consistent radiation courses (≤10 fractions) for bone metastases as well as the treatment, setting, patient characteristics and expenditures associated with such courses to better understand the potential for increasing value and cost savings under the RO Model.

MATERIALS AND METHODS

We analysed the RO model episode file, containing data on episodes of radiation treatment for Medicare fee-for-service beneficiaries during calendar years 2015–2017 that would qualify for the RO model[13] by treatment setting. Treatment settings included hospital-outpatient departments or free-standing centres. Detailed definitions of episodes are defined in the CMS documentation[13]; briefly, episodes were defined as having a cancer diagnosis code and treatment planning and delivery codes, with at least two bone metastases International Classification of Disease (ICD) codes (198.5x; C79.5x) occurring within 30 days and one radiation treatment delivery occurring within 28 days of the triggering planning service. Primary cancer type was not a variable captured in the dataset thus was unavailable. The episode captured all radiotherapy services (treatment consultation, treatment planning, technical preparation and special services (simulation), treatment delivery and treatment management, see reference for radiotherapy services codes[13] within 90 days from the initial treatment planning service. Expenditures included combined professional and technical fees, and were adjusted to 2017 dollars and winsorised (1st and 99th percentiles).[14] Treatment types included conventional external beam radiation therapy, intensity modulated radiation therapy (IMRT), stereotactic radiosurgery/stereotactic body radiotherapy (SRS/SBRT) and other treatment types (proton therapy, brachytherapy and intraoperative radiotherapy). Chemotherapy and major procedures occurring in the 90 days prior to or during the episode were also identified[13] as covariables.

Our primary outcome was receipt of ≤10 fractions, an indicator of higher-value radiation therapy.[6] We also evaluated a second value indicator, treatment complexity, by examining receipt of conventional external beam radiation versus more expensive modalities such as IMRT and episode expenditures.

First, we assessed differences in treatment and patient characteristics and treatment setting by receipt of ≤10 fractions compared with >10 fractions using χ^2 tests. Next, we evaluated unadjusted rates of receiving ≤10 fractions, by setting, treatment and patient characteristics. We then fit a multivariable logistic regression model to determine if treatment setting was an independent predictor of receiving ≤10 fractions, adjusting for treatment and patient variables. Treatment and patient variables adjusted for in the multivariable models included patient age group (<65, 65–74, 75–84, 85+), patient sex (male/female), major procedure within 90 days (yes/no) and receipt of chemotherapy within 90 days (yes/no). Variables excluded from the multivariable models were modality (such as SBRT) and death during the episode as these variables would potentially introduce instability into the model due to the number of fractions. Finally, we evaluated unadjusted expenditures using a generalised linear model (gamma distribution with log-link) by setting, treatment and patient characteristics. We then fit a multivariable model of expenditures by setting, adjusting for treatment and patient variables to estimate the independent contributors to differences in expenditures. A two-tailed $p<0.05$ was considered significant. Analyses were performed using R (V.3.6.1).

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Table 1 Characteristics of radiation oncology bone metastases episodes and unadjusted and adjusted analysis of receipt of 10 or fewer fractions of radiation for bone metastases

	Total, N (%)	>10 fractions, N (%)	≤10 fractions, N (%)	P value*
Overall	48 810 (100.0)	12 611 (25.8)	36 199 (74.2)	
Treatment setting				<0.001
Freestanding	20 516 (42.0)	7032 (55.8)	13 484 (37.2)	
Hospital-outpatient	28 294 (58.0)	5579 (44.2)	22 715 (62.8)	
Treatment type				<0.001
Conventional external beam	40 265 (82.5)	11 013 (87.3)	29 252 (80.8)	
IMRT	3916 (8.0)	1543 (12.2)	2373 (6.6)	
Other	1397 (2.9)	40 (0.3)	1357 (3.7)	
SRS/SBRT	3232 (6.6)	15 (0.1)	3217 (8.9)	
Age group				<0.001
<65	5672 (11.6)	1465 (11.6)	4207 (11.6)	
65–74	22 469 (46.0)	5981 (47.4)	16 488 (45.5)	
75–84	15 677 (32.1)	4020 (31.9)	11 657 (32.2)	
85+	4992 (10.2)	1145 (9.1)	3847 (10.6)	
Sex				0.06
Male	27 115 (55.6)	6915 (54.8)	20 200 (55.8)	
Female	21 695 (44.4)	5696 (45.2)	15 999 (44.2)	
Major procedure				0.29
No	34 014 (69.7)	8836 (70.1)	25 178 (69.6)	
Yes	14 796 (30.3)	3775 (29.9)	11 021 (30.4)	
Chemotherapy				<0.001
No	12 246 (25.1)	2886 (22.9)	9360 (25.9)	
Yes	36 564 (74.9)	9725 (77.1)	26 839 (74.1)	
Overall death during episode				<0.001
No	38 854 (79.6)	10 943 (86.8)	27 911 (77.1)	
Yes	9956 (20.4)	1668 (13.2)	8288 (22.9)	

*$\chi 2$.
IMRT, intensity modulated radiation therapy; SRS/SBRT, stereotactic radiosurgery/stereotactic body radiotherapy.

RESULTS

There were 48 810 episodes for bone metastases during the period, of which 28 294 (58%) occurred in the hospital-outpatient setting (table 1). Patients were primarily in the age groups 65–74 (N=22 469; 46.0%) and 75–84 (15,677; 32.1%) and were male (N=27 115; 55.6%). About one-third underwent a major procedure (N=14 796; 30.3%) and a three-quarters received chemotherapy (N=36 564; 74.9%) within the 90 days prior to the episode. Overall, 74% of episodes were for receipt of ≤10 fractions (13 484 of 20 516 (66%) received ≤10 fractions in free-standing centres, compared with 22 715 of 28 294 (80%) in hospital-outpatient centres). When evaluating episodes by receipt of ≤10 fractions, 37.2% (N=13 484) of episodes for ≤10 fractions occurred in free-standing centres, compared with 62.8% (N=22 715) in hospital outpatient settings, p<0.001.

Unadjusted and adjusted estimates of analysis of receipt of 10 or fewer fractions of radiation for bone metastases are shown in table 2. After adjusting for treatment and patient factors, hospital-outpatient treatment setting remained a significant predictor of receiving ≤10 fractions (adjusted OR 2.12 (95% CI 2.04, 2.21; p<0.001) compared with free-standing).

Unadjusted and adjusted estimates of expenditures associated with receipt of 10 or fewer fractions of radiation for bone metastases are shown in table 3. After adjusting for patient factors, the primary factors contributing to total expenditures were number of fractions (US$−3424 (95% CI US$−3412 to US$−3435) for ≤10 fractions vs >10; p<0.001) and treatment type (including US$7716 (95% CI US$7424 to US$8018) for IMRT compared with conventional external beam; p<0.001), with smaller estimated effects for treatment setting (US$110 (95% CI US$55 to US$168) for hospital-outpatient vs free-standing; p<0.001), age (US$−226 (95% CI US$−331 to −US$116), for age 85+ vs <65; p<0.001), chemotherapy (US$179 (95% CIUS$114 to US$246); p<0.001), major procedure

Table 2 Unadjusted and adjusted analysis of receipt of 10 or fewer fractions of radiation for bone metastases

	Unadjusted OR for receipt of ≤10 fractions (95% CI)	P value*	Adjusted OR for receipt of ≤10 fractions (95% CI)	P value*
Overall	--	--	2.09 (1.93 to 2.26)	<0.001
Treatment setting				
Freestanding	1.00		1.00	
Hospital-outpatient	2.12 (2.04 to 2.21)	<0.001	2.12 (2.04 to 2.21)	<0.001
Age group				
<65	1.00		1.00	
65–74	0.96 (0.90 to 1.03)	0.23	0.98 (0.92 to 1.05)	0.60
75–84	1.01 (0.94 to 1.08)	0.78	1.04 (0.97 to 1.12)	0.26
85+	1.17 (1.07 to 1.28)	<0.001	1.20 (1.10 to 1.32)	<0.001
Sex				
Male	1.00		1.00	
Female	0.96 (0.92 to 1.00)	0.06	0.95 (0.91 to 0.99)	0.02
Major procedure				
No	1.00		1.00	
Yes	1.03 (0.98 to 1.07)	0.28	1.02 (0.98 to 1.07)	0.35
Chemotherapy				
No	1.00		1.00	
Yes	0.85 (0.81 to 0.89)	<0.001	0.88 (0.84 to 0.93)	<0.001

*Logistic regression model.
CI, confidence interval; IMRT, intensity modulated radiation therapy; OR, odds ratio; SRS/SBRT, stereotactic radiosurgery/stereotactic body radiotherapy.

(US$71 (95% CI US$13 to US$131); p=0.02) and death during the episode (US$−815 (95% CI −US$863 to −US$765); p<0.001).

DISCUSSION

Delivery of higher-value radiation for bone metastases differs by treatment setting

Delivery of higher-value radiation for bone metastases differs by treatment setting in this nationwide sample of RO Model-defined episodes, with lower short course utilisation and higher IMRT utilisation in free-standing centres associated with higher expenditures. As compared with prior analyses of bone metastases using CMS data,[15–18] these data provide distinct and recent data on CMS-defined episodes of care. These findings are similar to Logan *et al*[15] who evaluated trends in fractionation and cost of bone metastasis radiation from 2011 to 2014 with 79.9% receiving 10 or fewer fractions in 2014 and demonstrating increased use in patients with advanced age. While we did not evaluate trends, our data likely represent a continuation of this trend, and validate the persistent performance gap using CMS episode criteria for the RO Model. We also found that the proportion of patients receiving short (≤10 fraction) courses of radiation in the hospital-outpatient setting are slightly lower than those reported using a quality measure approach with the limited 2018 reporting in Hospital Compare (80% vs 89%, respectively), though Hospital Compare likely selects for hospitals that performed well on the measure due to the ability to select reported measures. While the value of such short courses has been shown to be greater in appropriate patients, the inability to differentiate in this dataset between those who may benefit from specific regimens such as SRS, SBRT or IMRT, which are associated with higher costs but may be appropriate in select patients, such as certain patients with painful spinal metastases[19] or oligometastatic disease,[20] may also represent a limitation of the RO Model that should be investigated further to ensure flexibility for optimising individualised outcomes. We also validate single-institutional findings of differences in cost by treatment regimen for <10 fractions in a 90-day episode,[21] though our cost values were lower.

Potential impacts of the RO Model on palliative radiation of bone metastases

Given that the RO Model is site-neutral and modality agnostic, these findings suggest that the impact of the RO Model on palliative radiation of bone metastases will likely be greatest in free-standing centres and confirms the potential of the episode-based approach of the RO Model to improve value and provide cost savings for palliative radiation of bone metastases. It is not yet clear if these findings can be translated to treatment of other cancer types. It is possible that certain cancer types such as prostate cancer may provide another example of the potential

Table 3 Unadjusted and adjusted analysis of expenditures associated with receipt of 10 or fewer fractions of radiation for bone metastases

Covariable	Unadjusted mean difference (95% CI)	P value*	Adjusted mean difference (95% CI)	P value†
No of fractions				
>10	ref		ref	
≤10	–US$3070 (–3112 to –3027)	<0.001	–US$3424 (–3412 to –3435)	<0.001
Treatment setting				
Freestanding	ref		ref	
Hospital-outpatient	–US$457 (–526 to –387)	<0.001	US$110 (55 to 168)	<0.001
Treatment type				
Conventional external beam	ref		ref	
IMRT	US$6032 (5833 to 6235)	<0.001	US$7716 (7424 to 8018)	<0.001
Other	US$11 917 (11111 to 12776)	<0.001	US$20 220 (19401 to 21073)	<0.001
SRS/SBRT	US$6522 (6112 to 6956)	<0.001	US$11 845 (11422 to 12283)	<0.001
Age group				
<65	ref		ref	
65–74	US$114 (–11 to 245)	0.07	US$151 (63 to 243)	0.001
75–84	–US$259 (–377 to –136)	<0.001	–US$10 (–99 to 81)	0.82
85+	–US$793 (–921 to –658)	<0.001	–US$226 (–331 to –116)	<0.001
Sex				
Male	ref			
Female	US$35 (–40 to 111)	0.36	–US$18 (–70 to 36)	0.50
Major procedure				
No	ref		ref	
Yes	US$470 (384 to 559)	<0.001	US$71 (13 to 131)	0.02
Chemotherapy				
No	ref		ref	
Yes	US$174 (87 to 264)	<0.001	US$179 (114 to 246)	<0.001
Death during episode				
No	ref		ref	
Yes	–US$1652 (–1715 to –1587)	<0.001	–US$815 (–863 to –765)	<0.001

*Generalised linear model (gamma distribution with log link).
†Generalised linear model (gamma distribution with log link). Overall mean: US$8143 (95% CI US$8031 to US$8258), p<0.001.
IMRT, intensity modulated radiation therapy; SRS/SBRT, stereotactic radiosurgery/stereotactic body radiotherapy.

for improving value through integrating individualised care.[22] Providing resources to free-standing centres to develop and invest in the sustainability of palliative radiation programmes may help to facilitate successful RO Model participation, while incorporation of new data supporting advanced techniques is needed to ensure the model provides high-value care and optimal outcomes for individual patients. Emerging data support the use of SRS/SBRT to improve patient outcomes in select patients with bone metastases and may require re-evaluation of the RO Model to ensure that patients receive optimal value-based care.[19 20 23]

Study limitations

Our study is limited by the available data in the RO Model episode file, which does not include important patient characteristics such as performance status, prior radiation, presence of other metastases or site of radiation. However, the inclusion of patient characteristics such as age, receipt of a procedure or chemotherapy and death during the episode does account for casemix variation.[13] In addition, our findings are similar to other analyses showing ongoing use of more complex or longer courses of radiation in addition to greater use of longer courses in free-standing centres.[24–26] This suggests that the episode-based approach may capture the value of radiotherapy for bone metastases, though further exploration using patient-level data is needed and will be part of the ongoing evaluation of the programme.[13] In addition, our findings may not be generalisable to patients who are not Medicare fee-for-service beneficiaries, including many younger patients or patients who are not otherwise eligible for Medicare.

In conclusion, a measurable performance gap exists for the delivery of higher-value bone metastases radiotherapy under an episode-based model, associated with increased expenditures. The RO Model may succeed in improving the value of bone metastases radiation for Medicare beneficiaries. Increasing the capacity of free-standing centres to implement palliative-focused services may improve the ability of these practices to succeed under the RO Model.

Contributors Study concept and design: DM. Acquisition, analysis or interpretation of data: DM, MDA and KD. Drafting of the manuscript: DM. Critical revision of the manuscript for important intellectual content: DM, MDA and KD. Final approval of the version to be published: DM, MDA and KD. Agreement to be accountable for all aspects of the work: DM, MDA and KD. Overall content guarantor: DM.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study was did not meet the definition of human subjects research therefore did not require human subjects ethics review.

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Data availability statement Data are available in a public, open access repository. Research data are available at: https://innovation.cms.gov/innovation-models/radiation-oncology-model.

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