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Discharge status and post-discharge healthcare costs after skeletal-related event hospitalizations among medicare patients with bone metastatic solid tumors or multiple myeloma

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ABSTRACT

Background: Previous studies have quantified direct inpatient costs of skeletal-related events (SREs); however, costs associated with subsequent post-SRE care have not been examined.
Methods: We identified two study cohorts using 2011–2015 Medicare 20% sample data: patients diagnosed with 1) bone metastases from solid tumors or 2) multiple myeloma (MM), both with SRE-related hospitalization discharge dates January 1, 2011-September 30, 2015. We assessed discharge status and costs from discharge to the earliest of death, end of Medicare enrollment, or December 31, 2015. Discharge status was defined as: skilled nursing facility (SNF), rehabilitation facility, hospice, home health agency (HHA), long-term care (LTC) nursing home, LTC hospital, or rehospitalization within or after 30 days. Percentage, stay duration, and Medicare costs were calculated for each setting. All analyses were descriptive.
Results: We identified 7988 bone metastases patients and 4277 MM patients discharged from index SRE-related hospitalizations; corresponding mean ages were 76.9 and 76.6 years. The largest proportion of bone metastases patients were discharged to SNF (32.9%), then HHA (13.7%), hospice (13.5%), and LTC (11.3%); the pattern was similar for MM patients (SNF, 35.9%; HHA, 18.2%; hospice, 7.2%; LTC, 1.5%). Almost 10% of patients in both cohorts were re-hospitalized within 30 days. Mean Medicare cost per patient per facility stay was < $10,000 for hospice, and from $15,517 for LTC nursing home to $49,729 for LTC hospital for MM patients.
Conclusion: Most elderly cancer patients (>75%) require healthcare facility support after SRE-related hospitalization, with substantial associated costs. Post-discharge management is clinically and economically important.

1. Introduction

About 330,000 US adults developed bone metastases from solid tumors in 2012 [1]. These patients are at high risk for painful and costly bone complications, termed skeletal-related events (SREs), which include bone fractures, spinal cord compression, and radiation or surgery to the bone [2–4]. Patients with multiple myeloma (MM) are similarly at risk of SREs as a result of destructive bone lesions that are a defining characteristic of the disease [5]. >32,000 individuals were diagnosed with MM in 2019, with an estimated prevalence of>130,000 [6].

Previous studies using commercial claims databases show that healthcare resource utilization and economic burden are increased in adults with bone metastases [7–9] or MM [10,11] who experience SREs. A study using the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database also showed increased healthcare resource utilization and Medicare costs associated with incident SREs in men with prostate cancer metastatic to bone [12] One study of 569 Danish women with SREs secondary to breast cancer and bone metastases showed that patients with multiple SREs experienced more visits and longer hospitalization stays during the 90 days after an SRE than patients with a single SRE [13]

Previous studies have shown that hospitalization cost is the primary contributor to SRE cost [7–11]. Resource use and associated costs are likely to be substantial after SRE hospitalizations,

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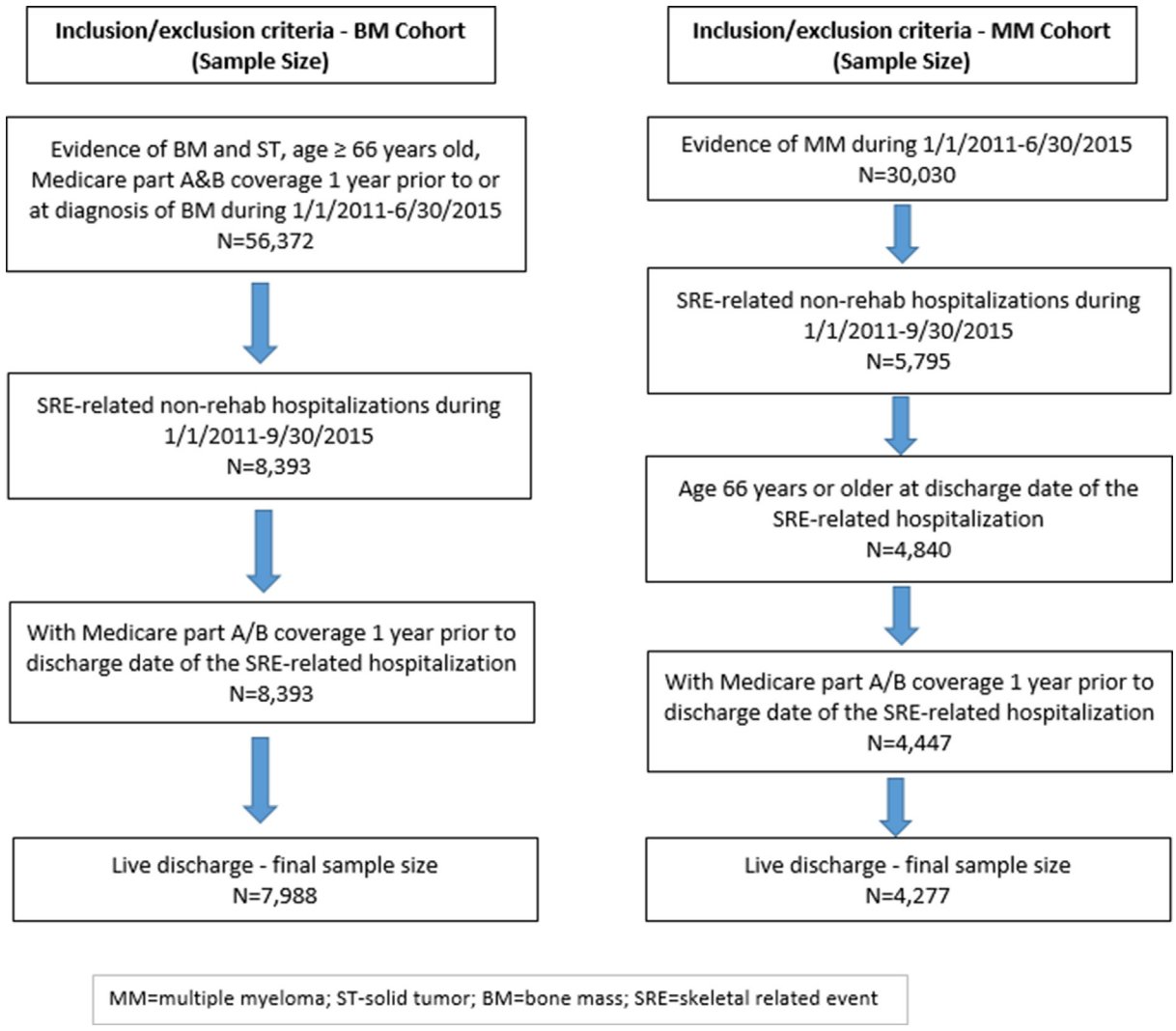


Fig. 1. Study design.

depending on hospital discharge status. Post-SRE hospitalization management and care is important, especially for older patients who require more comprehensive care. Medicare generally requires hospitals to engage in discharge planning to determine discharge locations for patients; however, because studies of post-discharge status after an SRE-related hospitalization are rare, data for use in such planning are lacking. A study of post-discharge status after total knee arthroplasty using Medicare data showed that 21% of patients were discharged to home, 38% to home health care, 31% to extended-care facilities, and 10% to rehabilitation [14]. In the general Medicare population, among>137 million hospital discharges, 26.3% were discharged to skilled nursing facilities (SNFs) or inpatient rehabilitation facilities [15]. In the current analysis, we aimed to understand discharge status and related post-discharge costs subsequent to an index SRE-related hospitalization among two cohorts of Medicare beneficiaries frequently affected by SREs: bone metastatic solid tumor patients and MM patients.

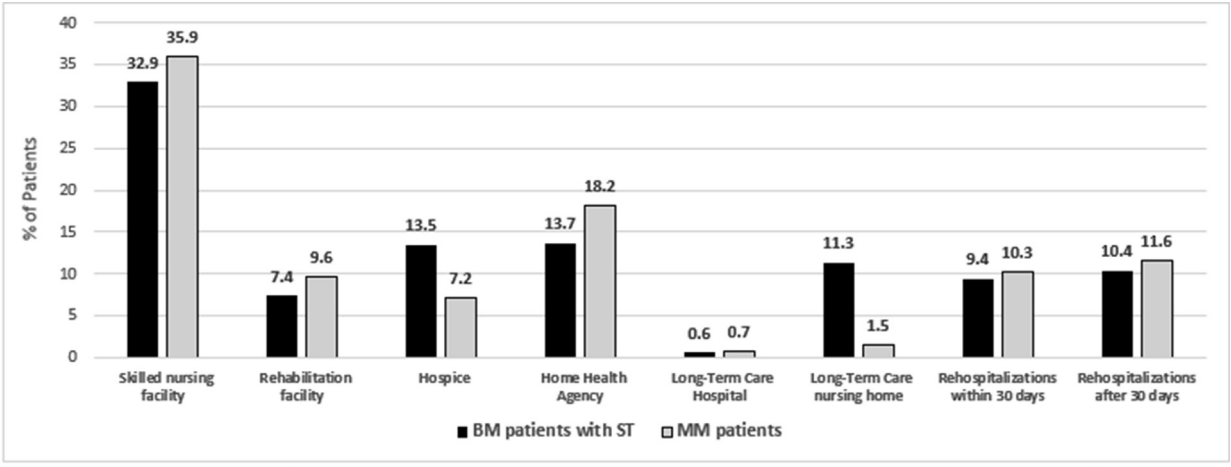
2. Methods

2.1. Study population and data Source

The study population included elderly fee-for-service (FFS) beneficiaries in the 2011–2015 Medicare 20% random sample. Medicare data include enrollment information, demographic characteristics, and medical claims from Part A, Part B, and Part D. The Medicare claims files contain information collected by Medicare to allow payment for healthcare services provided to Medicare beneficiaries in the US and its territories. Standard analytic files (SAFs) generated by the Centers for Medicare & Medicaid Services were used in this study. SAFs are available for each institutional claim type including inpatient, outpatient, SNF, home health agency (HHA), carrier, and hospice. Non-institutional Part B physician/supplier SAFs include final action claims for physician services, laboratory services (not laboratory values), and durable medical equipment (DME). Part D data include the prescription drug event file, which contains the National Drug Code for each drug, prescription dosing information, and drug costs. The 2011–2015 long-term care (LTC) Minimum Data Set (MDS) was used to identify LTC facility stays. The MDS is a standardized, primary screening and assessment tool for health status, which forms the foundation of the comprehensive assessment for all residents (regardless of payer) of LTC facilities certified to participate in Medicare or Medicaid.

2.2. Study cohorts and study design

This study included two study cohorts: (1) patients with bone metastases from solid tumors and (2) patients with MM. Patients



	All	Skilled nursing facility	Rehabilitation facility	Hospice	Home Health Agency	Long-Term Care Hospital	Long-Term Care nursing home	Re-hospitalizations within 30 days	Re-hospitalizations after 30 days
BM Patients with ST	7,988	2,629	588	1,076	1,094	47	904	754	831
MM Patients	4,277	1,535	412	306	780	30	65	442	495

Fig. 2. Sample selection and sample size.

with bone metastases were identified by at least one inpatient claim or two outpatient claims on different days within a 12-month interval carrying the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code for secondary malignant neoplasm of bone or bone marrow (198.5). The bone metastasis date was defined as the earliest of (1) discharge date for inpatient claims and (2) second outpatient date. This algorithm is based on two previously published studies aiming to estimate prevalence of bone metastases using a Medicare FFS sample and the Truven Marketscan and PharMetrics Plus commercial claims databases [1,16]. Solid tumor types included prostate, breast (female only), lung, and other cancers during a 12-month interval before bone metastases were identified. ICD-9-CM diagnosis codes for specific cancer types appear in Appendix A. Cancer types were defined by at least one inpatient claim or two outpatient claims on different days in the 12-month interval. The following inclusion criteria were applied: (1) evidence of bone metastases from a solid tumor and subsequent SRE-related hospitalization (i.e., index SRE hospitalization) with discharge dates (i.e., index dates) between January 1, 2011, and September 30, 2015, (2) age $\geq$ 66 years on the index date, and (3) continuously enrolled in Medicare Parts A and B for $\geq$ 12 months before and on the index date. The following exclusion criteria were applied: (1) evidence of two or more solid tumors, (2) death on the index date, and (3) enrollment in a Medicare Advantage plan anytime during the 12 months before or on the index date.

Similarly, we defined patients with MM based on a validated algorithm requiring a combination of ICD-9-CM diagnosis codes (Appendix B) and diagnostic tests or treatment [17]. The following inclusion criteria were applied: (1) evidence of MM between January 1, 2011, and June 30, 2015; (2) evidence of subsequent SRE-related hospitalization (i.e., index SRE hospitalization) with discharge date (i.e., index dates) between January 1, 2011, and September 30, 2015; (3) age $\geq$ 66 years on the index date; and (4) continuously enrolled in Medicare Parts A and B for $\geq$ 12 months before and on the index date. The following exclusion criteria were applied: (1) death on the index date and (2) enrollment in a Medicare Advantage plan during the study period.

The detailed study design is displayed in Fig. 1. For both study cohorts, the baseline period was 1 year prior to the index date. During the baseline period, patient demographics, Medicare/Medicaid dual eligible status, pre-index SRE-related hospitalizations (including the index SRE hospitalizations), and Charlson comorbidity index (CCI) were defined. The follow-up period was from the index date to the earliest of date of death, end of Medicare enrollment in both Part A and B, enrollment in a Medicare Advantage program, or December 31, 2015. During the follow-up period, we identified post-discharge facilities after index SRE hospitalizations and assessed lengths of stay and Medicare costs during the stays. We also assessed re-hospitalization within and after 30 days.

2.3. Defining SREs

We used a claims-based algorithm to define SREs. Different methods have been used to identify SREs using claims in previous studies. In a recent study, Aly et al. compared different methods of identifying SREs from claims using Medicare-SEER data [18]. The current study adopted the method developed by Aly et al. and defined SREs with a 21-day window. SRE types included: spinal cord compression, fracture, and surgery or radiation to the bone. Codes and algorithms appear in Appendix C.

2.4. Defining discharge status from the index SRE hospitalization

As required by Medicare, discharging hospitals report patient discharge status using Discharge Disposition codes (e.g., code 03 identifies a SNF). However, in our exploratory analysis we found that the admitting facility subsequent to the index SRE hospitalization was not always the same as was indicated by the Discharge Disposition code provided by the discharging hospital, possibly due to claim error [19]. Therefore, we used the actual admitting facilities subsequent to index SRE hospitalizations to define discharge status.

Discharge status after the index SRE hospitalization was defined as admission to: SNF, rehabilitation facility, hospice, HHA, LTC hospital, LTC nursing home, re-hospitalization for any reason within 30 days, or re-hospitalization after 30 days.

Table 1
Baseline Characteristics.

Characteristics	Patients Bone Metastatic Solid Tumor *n*	%	Multiple Myeloma *n*	%
n	7988		4277	
Age; mean (SD)	76.9 (7.3)		76.6 (7.1)	
Age category, yrs.				
66–69	1501	18.8	826	19.3
70–74	1976	24.7	1089	25.5
75–79	1665	20.8	856	20.0
≥ 80	2846	35.6	1506	35.2
Sex				
Male	4026	50.4	1895	44.3
Female	3962	49.6	2382	55.7
Race				
White	7026	88.0	3530	82.5
Black	647	8.1	570	13.3
Other	315	3.9	177	4.1
Medicare-Medicaid dual eligible				
No	6966	87.2	3708	86.7
Yes	1022	12.8	569	13.3
Geographic region				
Northeast	1835	23.0	968	22.6
Midwest	2008	25.1	1029	24.1
South	2912	36.5	1602	37.5
West	1222	15.3	669	15.6
Missing	11	0.1	*	*
Pre-index SRE-related hospitalization LOS, days; mean (SD)[†‡]	8.4 (9.1)		10.6 (10.4)	
Pre-index SRE-related hospitalization LOS categories, days[†‡]				
1–3	1661	20.8	803	18.8
4–7	3109	38.9	1392	32.5
≥ 8	3218	40.3	2082	48.7
CCI categories[†]				
0–4	118	1.5	2019	47.2
5–8	2638	33.0	1269	29.7
≥ 9	5232	65.5	989	23.1
Tumor type[§]				
Breast cancer	1582	19.8	–	–
Prostate cancer	1743	21.8	–	–
Lung cancer	2393	30.0	–	–
Other cancer	2270	28.4	–	–

[‡]Including index SRE hospitalization.
CCI, Charlson comorbidity index; LOS, length of stay; SD, standard deviation; SRE, skeletal related event.
* Cells with *n* less than 11 suppressed.
† Defined during the baseline period, i.e., one year prior to SRE index date which was the discharge date of the SRE-related hospitalization.
§ Defined during the 1 year prior to the bone metastases index date.

Table 2
Length of Stay for the SRE Index Hospitalizations by Study Cohorts.

Facility admission type after discharge from SRE-related hospitalization	Patients Bone Metastases from Solid Tumors *n*	Mean	SD	Median	IQR	Multiple Myeloma *n*	Mean	SD	Median	IQR
All	7988	8.2	8.9	6	(4,10)	4277	8.0	7.6	6	(4,10)
Skilled nursing facility	2629	9.4	7.0	7	(5,12)	1535	8.9	7.0	7	(4,11)
Rehabilitation facility	588	8.0	5.4	7	(4,10)	412	8.2	6.8	6	(4,10)
Hospice	1076	9.3	13.2	7	(4,12)	306	9.8	9.6	7	(4,13)
HHA	1094	8.0	12.6	6	(4,10)	780	7.3	6.9	5	(3,9)
LTC hospital	47	16.6	13.4	12	(7,18)	30	21.1	17.1	14.5	(9,28)
LTC nursing home	904	8.4	6.7	7	(4,10)	65	11.3	16.7	6	(3,10)
Re-hospitalizations within 30 days after SRE discharge	754	7.0	6.3	5	(3,9)	442	6.9	7.5	5	(3,8)
Re-hospitalizations after 30 days of SRE discharge	831	5.5	5.3	4	(3,7)	495	5.7	5.6	4	(2,7)

HHA, home health agency; IQR, inter-quartile range; LTC, long-term care; SD, standard deviation; SRE, skeletal related event.

Except for LTC nursing homes, facilities were identified from Medicare Part A institutional claims and admissions were mutually exclusive. LTC nursing homes were identified from MDS data. Some patients were admitted to an LTC nursing home directly from the index SRE hospitalization. Only a few patients (less than 1%) were admitted directly to home without being admitted to any facility (including re-hospitalization) during follow-up.

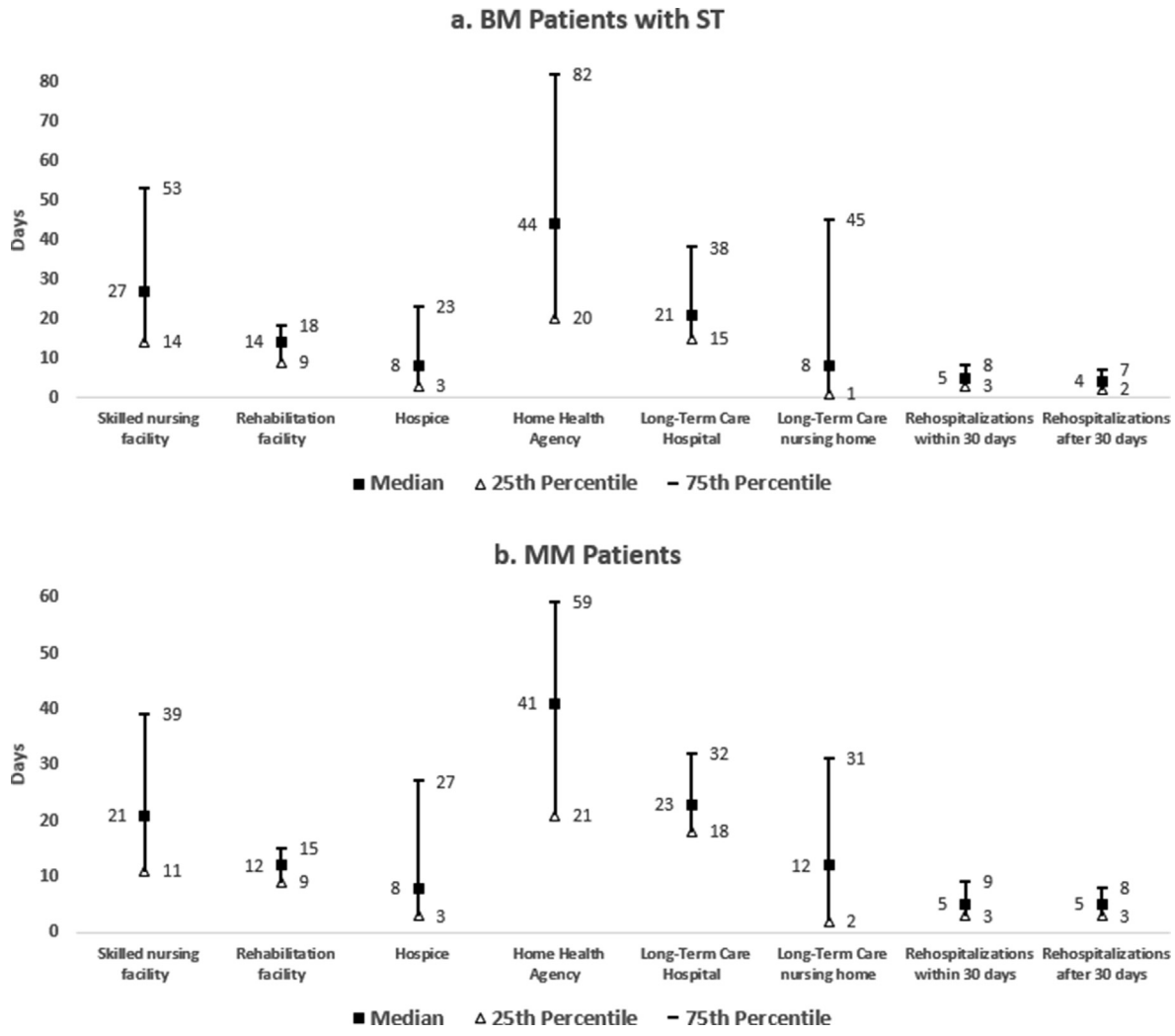


Fig. 3. Number and percentage of patients discharged to different facilities after the SRE index hospitalization by study cohort. BM, bone metastasis; MM, multiple myeloma; SRE, skeletal-related event; ST, solid tumor.

2.5. Defining Medicare costs in an admitting facility after discharge from the index SRE hospitalization

The definition of Medicare costs was the same for all facilities except LTC nursing homes. Using SNFs as an example: When a patient was admitted to a SNF, Medicare costs included those for the SNF itself, outpatient services, physician visits/DME, and pharmacy costs defined from Medicare Part D claims. We included both Medicare paid amounts and patient or third party paid amounts, i.e., Medicare allowable. We calculated total Medicare allowable costs in a SNF and mean cost per SNF, dividing the total cost in the SNF by its total number of patients. Costs were adjusted to the 2015 US dollar.

Costs for LTC nursing homes were estimated by multiplying the length of LTC nursing home stays in days by the 2015 national daily nursing home cost of $235 per day [20]. We included other Medicare-covered costs such as outpatient services, physician visits/DME, and pharmacy during the LTC nursing home stay in the total cost.

2.6. Statistical analyses

All analyses were descriptive. For patient characteristics, we report number and percentage for categorical variables and mean (standard deviation [SD]) for continuous variables. For discharge status, we report number, percentage, and length of stay for each facility. The length of stay is reported as mean, SD, median, and interquartile range. For Medicare costs, we report mean, median, and SD cost for each facility.

3. Results

3.1. Patient characteristics

We identified 7988 (not including 405 deaths at discharge) patients with bone metastases from solid tumors and a subsequent SRE-related hospitalization. Separately, we identified 4277 (not including 170 deaths at discharge) patients with MM and a subsequent SRE-related hospitalization. Sample selection for both study cohorts is shown in Fig. 2 with inclusion and exclusion criteria. Baseline characteristics for both study cohorts are presented in Table 1.

For bone metastases patients, mean (SD) age was 76.9 (7.3) years; 49.6% were women, 88.0% white, and 8.1% black. Mean (SD) length of pre-index SRE-related hospitalization (including the index SRE hospitalization) at baseline was 8.4 (9.1) days and mean (SD) CCI was 9.4 (1.9). Among the cancer types defined during the 1 year prior to the bone metastases diagnosis date, 19.8%

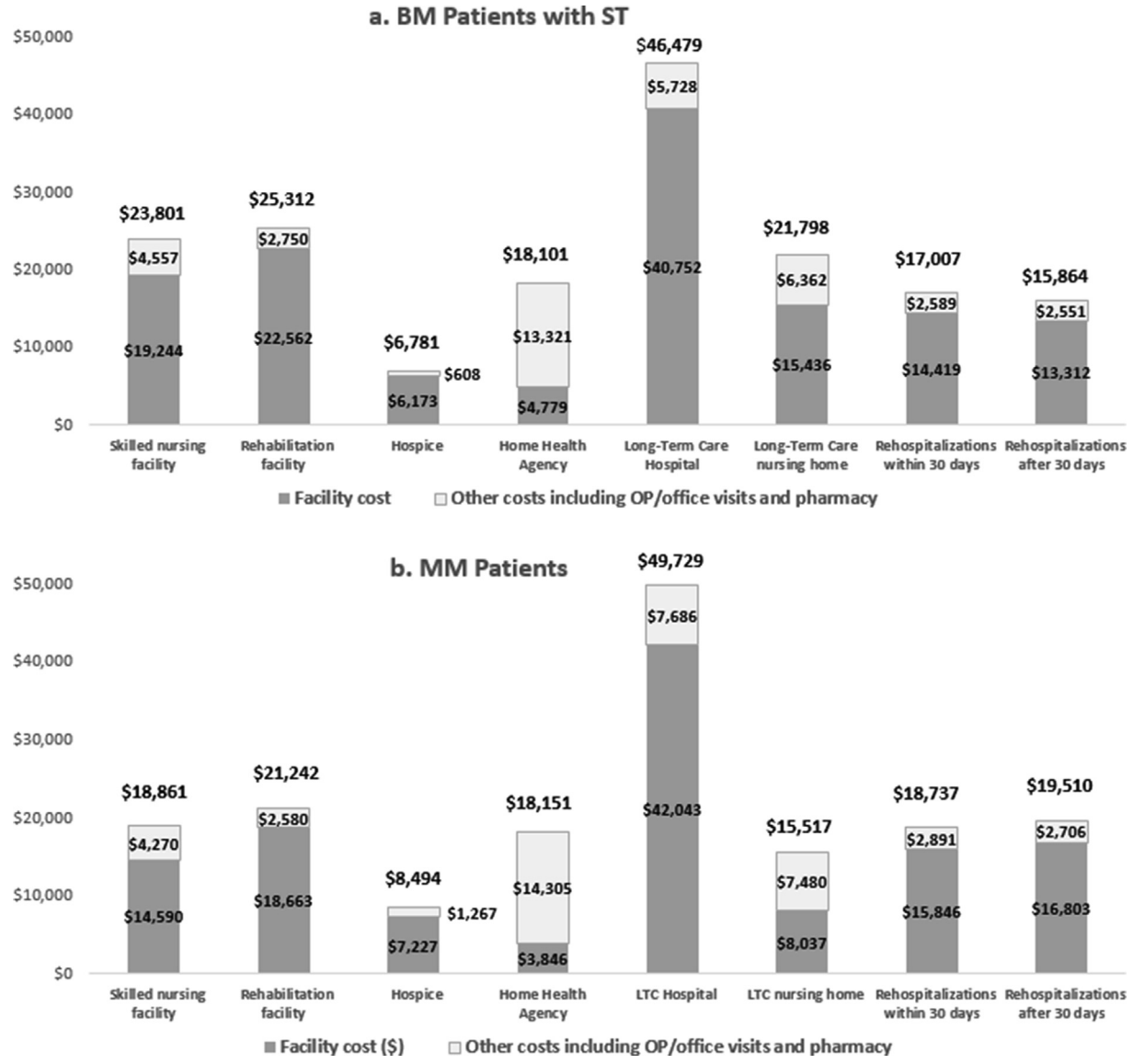


Fig. 4. Distribution of length of stay in each facility after discharge from a SRE-related index hospitalization by study cohorts. BM, bone metastasis; MM, multiple myeloma; SRE, skeletal-related event; ST, solid tumor.

had breast cancer, 21.8% prostate cancer, 30.0%, lung cancer, and 28.4% other cancers. As shown in Table 2, the mean (SD) length of the index SRE hospitalization was 8.2 (8.9) days overall. Index SRE hospitalizations were longest for patients discharged to LTC hospitals, mean (SD) 16.6 (13.4) days, followed by patients discharged to SNFs, mean (SD) 9.4 (7.0) days.

For patients with MM, mean (SD) age was 76.6 (7.1) years; 55.7% were women, 82.5% white, and 13.3% black. Mean (SD) length of pre-index SRE-related hospitalization (including the index SRE hospitalization) at baseline was 10.6 (10.4) days and mean (SD) CCI 5.6 (3.3). As shown in Table 2, the mean (SD) length of index SRE hospitalization was 8.0 (7.6) days overall. Index SRE hospitalizations were longest for patients discharged to LTC hospitals, mean (SD) 21.1 (17.1) days, followed by patients discharged to LTC nursing homes, mean (SD) 11.3 (16.7) days.

3.2. Discharge status from the index SRE hospitalization

As shown in Fig. 3, the largest proportion of patients from the bone metastases cohort were discharged to SNF (32.9%), followed by HHA (13.7%), hospice (13.5%), and LTC (11.3%). The pattern was similar for the MM cohort (SNF, 35.9%; HHA, 18.2%; hospice, 7.2; LTC, 1.5%. Almost 10% of both cohorts were re-hospitalized within 30 days of discharge.

3.3. Length of stay at each admitting facility after discharge from index SRE hospitalization

Median and inter-quartile range of lengths of stay at each admitting facility after discharge from index SRE hospitalizations are shown in Fig. 4 for both study cohorts. For bone metastases patients, the longest length of stay was for HHA, with a median of 44 days, followed by SNF (median 27 days), and LTC hospital (median 21 days). For MM patients, the longest length of stay was for HHA (median 41 days) followed by LTC hospital (median 23 days), and SNF (median 21 days).

3.4. Medicare cost at each admitting facility after discharge from index SRE hospitalization

Mean Medicare costs per patient for each admitting facility after discharge from the index SRE hospitalization are presented

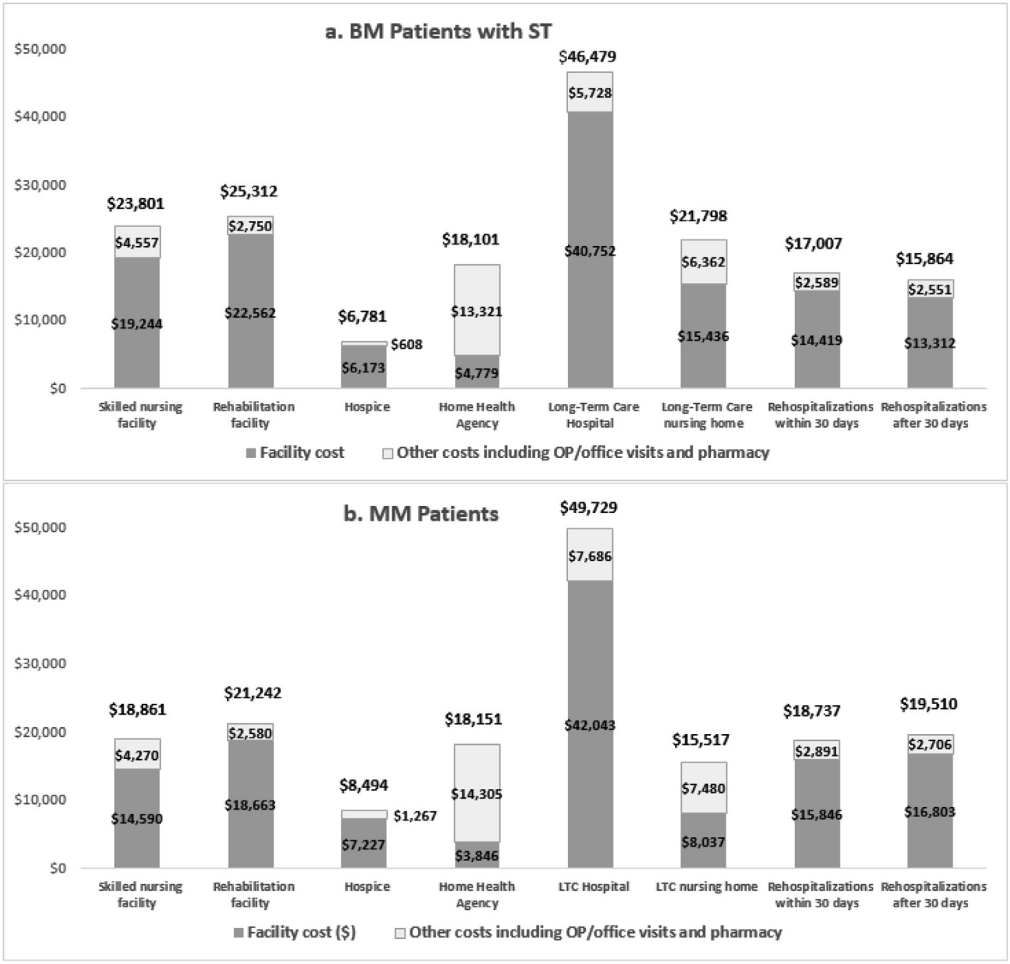


Fig. 5. Medicare cost for each facility after discharge from a SRE-related index hospitalization by study cohorts, mean Medicare allowable per patient per facility, in 2015 $. BM, bone metastasis; LTC, long-term care; MM, multiple myeloma; OP, outpatient; SRE, skeletal-related event; ST, solid tumor.

in Fig. 5. Except for HHA, the primary cost (>80%) was for the facility itself. For bone metastases patients, the most expensive facility was LTC hospital (mean cost per patient $46,479), followed by rehabilitation facilities (mean cost $25,312), and SNFs (mean cost $23,801). Mean cost per patient for other facilities (not including hospice, mean $6781) ranged from $15,864 to $21,798. For MM patients, the most expensive facility was LTC hospital (mean cost per patient of $49,729), followed by rehabilitation facilities (mean cost $21,242). Mean costs for other facilities (not including hospice, mean $8494) ranged from $15,517 to $19,510. Detailed mean, median, and SD costs per patient per facility overall and by each service category of services are reported in Table 3.

Total Medicare costs by discharge facility are reported in Table 4, with ranges from $2.18 million (LTC hospital) to $62.57 million (SNF) for bone metastases patients, and from $1.01 million (LTC nursing home) to $28.95 million (SNF) for MM patients. Estimated total Medicare costs for all facilities combined were $152.46 million for 7923 bone metastases patients and $74.69 million for 4054 MM patients.

4. Discussion

In this study, we examined post-discharge healthcare resource use and costs for patients with SRE-related hospitalizations in two cohorts: elderly patients with bone metastases from solid tumors and elderly patients with MM, using Medicare 20% sample data for 2011–2015. Percentages of patients discharged to institutional post-acute care (i.e., SNF and rehabilitation facility) were 40.3% (32.9% SNF and 7.4% rehabilitation) and 45.5% (35.9% SNF and 9.6% rehabilitation) for patients with bone metastases and MM, respectively. These percentages are higher than in the general Medicare population, reported to be 26.3% in 2015 [15]. Percentages of discharges to SNF alone in our study were 32.9% for bone metastases patients and 35.9% for MM patients. In the general Medicare population, the percentage discharged to SNFs from hospital was reported to be about 20% in 2016 [21]. Percentages of discharges to rehabilitation facilities alone in our study were 7.4% for bone metastases patients and 9.6% for MM patients. In the general Medicare population, the percentage was about 4% in 2015 [22]. In addition, about 9%-10% of patients were readmitted to hospital within 30 days of discharge from the index SRE hospitalization. The mean length of index SRE hospitalizations was about 8 days for the two cohorts, longer than in the general elderly Medicare population, reported as 5.8 days in 2015 [23]. Post-discharge SNF stays were much longer than in general Medicare population: 40.5 days for bone metastases patients and 31.2 days for MM patients, versus 26.5 days in 2015 for elderly Medicare patients [23].

We estimated post-discharge costs after an index SRE hospitalization for the two study cohorts. For bone metastases patients and for MM patients, the most expensive post-discharge care took

Table 3
Medicare Cost of Each Facility After Discharge from a SRE-related Index Hospitalization by Source of Cost and by Study Cohorts, Mean Medicare Allowable Per Patient Per Facility, in 2015 $.

Facility admission type after discharge from a SRE-related hospitalization	Patients Bone Metastases from Solid Tumors Facility cost ($)	OP visit cost ($)	Physician & DME cost ($)	Pharmacy cost ($)	Total cost ($)	Multiple Myeloma Facility cost ($)	OP visit cost ($)	Physician & DME cost ($)	Pharmacy cost ($)	Total cost ($)
	Mean: Medicare allowable amount ($)									
SNF	19,244	1426	2511	621	23,801	14,590	1,519	2023	729	18,861
Rehabilitation facility	22,562	118	2464	168	25,312	18,663	118	2056	405	21,242
Hospice	6,173	84	416	108	6781	7227	110	431	727	8494
HHA	4779	4245	6675	2402	18,101	3846	4555	5746	4004	18,151
LTC hospital	40,752	222	5128	377	46,479	42,043	531	5471	1683	49,729
LTC nursing home	15,436	2088	2117	2156	21,798	8037	2,118	2283	3079	15,517
Re-hospitalizations within 30 days after SRE discharge	14,419	98	2411	80	17,007	15,846	141	2528	222	18,737
Re-hospitalizations after 30 days of SRE discharge	13,312	160	2289	102	15,864	16,803	108	2275	323	19,510
	Median: Medicare allowable amount ($)									
SNF	13,524	137	1565	0	16,718	10,984	0	1251	0	14,367
Rehabilitation facility	20,114	0	1942	0	22,312	18,152	0	1743	0	20,640
Hospice	3145	0	341	0	3548	3612	0	303	0	3984
HHA	3227	1024	2345	50	9632	3014	834	2176	144	11,488
LTC Hospital	34,159	0	3730	0	39,917	35,801	0	3888	0	41,512
LTC nursing home	1880	0	435	15	3360	2820	354	1076	8	4585
Re-hospitalizations within 30 days after SRE discharge	10,327	0	1683	0	12,243	10,484	0	1643	0	12,734
Re-hospitalizations after 30 days of SRE discharge	9698	0	1607	0	11,583	10,789	0	1616	0	13,305
	SD: Medicare allowable amount ($)									
SNF	18,039	3184	3036	4488	22,277	12,523	4,981	2,845	3084	16,895
Rehabilitation facility	13,488	479	2080	834	14,931	7709	843	1,600	1735	8671
Hospice	9949	775	506	754	10,449	12,977	801	734	10,643	19,921
HHA	5107	11,026	12,731	8864	25,443	3697	11,346	9314	10,736	22,422
LTC Hospital	33,686	702	4362	1504	36,832	25,803	1768	5048	3571	29,230
LTC nursing home	35,768	7969	5933	11,893	51,732	15,925	3568	4645	17,028	34,706
Re-hospitalizations within 30 days after SRE discharge	16,513	428	2656	531	18,417	15,686	704	2684	1244	17,874
Re-hospitalizations after 30 days of SRE discharge	18,613	880	2459	622	20,409	16,787	549	2463	1482	18,036

HHA, home health agency; LTC, long-term care; SNF, skilled nursing facility; SRE, skeletal-related event.

Table 4
Total Medicare Allowable Cost in 2015 $ of Each Facility After Discharge from a SRE Index Hospitalization by Study Cohorts.

Facility admission type after discharge from a SRE-related hospitalization	*n* of SRE-related IP claims*	Total Length of Stay (days)	Total Medicare allowable amounts ($) Facility cost ($)	OP visit cost ($)	Physician & DME cost ($)	Part D pharmacy cost ($)	Total cost ($)
	Patients with Bone Metastases from Solid Tumors						
Skilled nursing facility	2629	106,522	50,593,606	3,747,784	6,600,707	1,631,537	62,573,635
Rehabilitation facility	588	9093	13,266,579	69,184	1,448,861	98,815	14,883,439
Hospice	1076	27,833	6,642,439	90,165	447,774	115,913	7,296,291
HHA	1094	74,081	5,228,396	4,643,555	7,301,941	2,628,212	19,802,104
LTC Hospital	47	1326	1,915,340	10,451	241,030	17,715	2,184,536
LTC nursing home	904	59,379	13,954,065†	1,887,954	1,914,208	1,949,162	19,705,388
Re-hospitalizations within 30 days after SRE discharge	754	5,221	10,871,590	73,845	1,817,735	60,377	12,823,548
Re-hospitalizations after 30 days of SRE discharge	831	4,643	11,062,507	132,977	1,902,287	84,888	13,182,659
	Patients with Multiple Myeloma						
Skilled nursing facility	1,535	47,920	22,396,049	2,331,456	3,104,533	1,119,182	28,951,219
Rehabilitation facility	410	5,088	7,651,718	48,376	843,040	166,186	8,709,321
Hospice	306	9,600	2,211,311	33,581	131,758	222,486	2,599,136
HHA	779	45,469	2,995,893	3,548,484	4,476,284	3,118,916	14,139,578
LTC Hospital	30	856	1,261,299	15,941	164,138	50,486	1,491,864
LTC nursing home	65	2,223	522,405	137,653	148,406	200,141	1,008,606
Re-hospitalizations within 30 days after SRE discharge	437	3,175	6,924,657*	61,639	1,104,629	97,013	8,187,938
Re-hospitalizations after 30 days of SRE discharge	492	3,307	8,267,319	53,252	1,119,476	158,818	9,598,864

HHA, home health agency; LTC, long-term care; SRE, skeletal-related event.
* Excluding those with total cost of zero.
† Total LTC nursing facility cost was estimated through multiplying days of LTC stay by 2015 US average daily nursing home cost. Patient's daily LTC costs were $235 per day, average of daily semi-private and daily private room. Source: http://skloff.com/cost-of-long-term-care-by-state-2015/

place at SNFs. Total Medicare allowable costs at SNFs after discharge from the index SRE hospitalization for both cohorts combined was about $91.52 million, about 40.3% of total post-discharge care. The extrapolated estimate of the same Medicare expenditures for the same patients in the entire Medicare population would be at least $457.6 ($91.52*5) million in the study period. The mean per patient cost in these patient populations after discharge from a SRE-related hospitalization was higher than for the general Medicare population across all facilities. The mean costs at SNFs were $23,801 for bone metastases patients and $18,861 for MM patients. In the general elderly Medicare population, the mean cost per SNF admission in 2015 was $11,545 [23]. The mean costs for readmission within 30 days were $17,007 for bone metastases patients and $18,737 for MM patients. In the general elderly Medicare population, the mean cost per discharge in 2015 was $11,750 [23]. Mean (median) costs at rehabilitation facilities were $25,312 ($22,312) for bone metastases patients and $21,242 ($20,640) for MM patients, versus the median cost of $11,124-$19,443 in the 2015 in general Medicare population [22]. Mean (median) costs at LTC hospitals were $46,479 ($39,917) for bone metastases patients and $49,729 ($41,512) for MM patients, versus the mean cost of $40,718 in the 2015 general Medicare population [22].

This study has strengths and limitations. To our knowledge, it is the first study to examine discharge status and post-discharge spending for cancer patients subsequent to SRE hospitalization, an important cost component to consider. Medicare is a large US federal government program; among adults aged 65 years or older, 93.7% were insured under a government plan (primarily Medicare) [24]. Therefore, our study results are representative of the US Medicare population with the same disease conditions. Regarding limitations, first, these results are limited to Medicare beneficiaries and cannot be extrapolated to the US general population. Second, this study used claims-based algorithms to define bone metastases, MM, and SREs. Although these definitions have been widely used in previous studies, the entire medical history cannot be obtained from claims data; therefore, the case estimates may be imperfect.

In conclusion, this study provides estimates of discharge status and post-discharge costs after an index SRE hospitalization for elderly Medicare patients with bone metastases from solid tumors and patients with MM in the study period 2011–2015. Compared with the general Medicare population, in the study samples, percentages of admissions to institutional post-acute care facilities such as SNFs, rehabilitation facilities, or LTC facilities were higher, stays in those facilities were longer, and resulting total Medicare costs were higher. Most elderly patients with SRE-related hospitalizations (>75%) were discharged to subsequent healthcare facilities, associated with substantial costs. Post-discharge management after SRE hospitalization is clinically and economically significant for elderly patients, has significant implications for public health, and highlights the need for primary prevention of these painful and costly events.

CRediT authorship contribution statement

Suying Li: Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Haifeng Guo:** Formal analysis, Writing - review & editing. **Yi Peng:** Formal analysis, Methodology, Writing - review & editing. **Tingting Gong:** Formal analysis, Writing - review & editing. **Alan Fu:** Conceptualization, Methodology, Writing - review & editing. **Debajyoti Bhowmik:** Conceptualization, Writing - review & editing. **Rohini K. Hernandez:** Conceptualization, Writing - review & editing. **Katherine B. Carlson:** Conceptualization, Writing - review & editing. **Kimberly A. Lowe:** Conceptualization, Writing - review & editing. **Jitesh Rana:** Conceptualization, Writing - review & editing. **Shuling Li:** Conceptualization, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Appendix A
International Classification of Diseases, Ninth Edition, Clinical Modification diagnosis codes used to identify solid tumors.

Cancer Types	Diagnosis Codes
Head and neck	140.x-149.x
Esophagus	150.x
Stomach and small intestine	151.x, 152.x
Colon and rectum	153.x, 154.x
Liver	155.x
Gallbladder	156.x
Pancreas	157.x
Retroperitoneum and peritoneum	158.x
Spleen	159.x
Lung	162.x
Other respiratory	160.x-161.x, 163.x, 164.x-165.x
Bone	170.x
Connective and soft tissue	171.x
Melanoma	172.x
Female breast	174.x
Male breast	1750 or 1759
Sarcoma	176.x
Gynecologic	179.x-184.x
Prostate	185
Other genitourinary	186.x-189.x
Central nervous system	190.x-192.x
Endocrine	193.x, 194.x
Other and ill defined	195.x, 199.x

Appendix B
International Classification of Diseases, Ninth Edition, Clinical Modification diagnosis codes used to identify multiple myeloma.

Description	Code
Multiple myeloma without mention of having achieved remission	203.00
Multiple myeloma in remission	203.01
Multiple myeloma in relapse	203.02

Appendix C
Codes and algorithm to identify skeletal-related events (SREs).

Event	ICD-9/CPT/HCPCS Codes	Number/Type of Claims to Qualify for Case Definition
Skeletal Related Events (SRE) (will use algorithm of "base case" definition from Aly et al.)	Spinal Cord Compression: ICD-9 diagnosis codes: 336.9 (unspecified disease of the spinal cord) ICD-10 diagnosis codes: G061, G07, G9520, G9529, G959 HCPCS codes: 63050, 63051, 22551, 22552, 63064, 63066, 61343, S2348, 63075–8, S2350, S2351, 63195, 63197, 63199, 63001, 63003, 63005, 63011, 63015, 63016, 63017, 63170, 63012, 63045, 63046, 63047, 63048, 63040, 63042, 63043, 63044, 63020, 63030, 63035, 22224, 22222, 22214, 22212, 22207, 22206, 0274 T, 0275 T, C9729, 0202 T, 22865, 0164 T, 0094 T, 0097 T, 63057, 63056, 63055, 63081, 63082, 63087, 63088, 63101, 63102, 63103, 63090, 63091, 63086, and 63,085	1 Part A or 1 Part B
	Pathologic Fracture: ICD-9 diagnosis codes for pathologic fracture: 733.1X (pathologic fracture) ICD-10 diagnosis codes for pathologic fracture: not listed in this table. ICD-9 diagnosis codes for other fracture: 8202, 8208, 8210, 8212, 8120, 8122, 8124, 8130, 8132, 8134, 8138, 8230, 8232, 8238, 805, 806, 8200, 800, 807, 8080, 8082, 8084, 8088, 8100, 8240, 8242, 80841, 80842, 80843, and 80849; ICD-10 diagnosis codes for other fracture: not listed in this table ICD-9 diagnosis codes for trauma/non-routine falls/accidents: 819, 828, 851, 852, 853, 854, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 9584, E800-E848, E881, E882, E883, E884.0, E884.1, E884.5, E885.0, E885.1, E885.2, E885.3, E885.4, E886.0, E886.9, E888.0, and E888.1 ICD-10 diagnosis codes for Trauma: not listed in this table	1 Part A or 1 Part B indicating "pathologic fracture" and "other fracture" excluding codes suggesting concurrent accidents/fall defined as within 2 weeks ending with the fracture
	Bone Palliative Radiotherapy: ICD-9 procedure codes: 92.23, 92.24, 92.29 ICD-10 procedure codes for Radiotherapy: not listed in this table HCPCS codes: A9600, A9604, A9605, C9401, J3005, 77401, 77402, 77403, 77404, 77406, 77407, 77408, 77409, 77411, 77412, 77413, 77414, 77416, 77418, 79005, 79101, 79200, 79300, 79400, 79403, 79440, 79445, 79999, and new from 2015 including G6003-G6015 (for radiation in office) and 77385–77386 (for hospital outpatient) and HCPCS codes: G6003-G6015 and CPT codes: 77,385 and 77,386	1 Part A or 1 Part B claim indicating receipt of EBRT (2D and 3D) or radioisotopes
	Bone Surgery: ICD-9 procedure codes: 7815, 7845, 7855, 7915, 7925, 7935, 7995, 7812, 7842, 7852, 7911, 7921, 7931, 7991, 7813, 7843, 7853, 7912, 7922, 7932, 7992, 7817, 7847, 7857, 7916, 7926, 7936, 7996, 0353, 8102, 8103, 8104, 8105, 8106, 8107, 8108, 7810, 7811, 7816, 7819, 7840, 7841, 7846, 7849, 7850, 7851, 7856, 7859, 7910, 7919, 7920, 7929, 7930, 7939, 7990, and 7999 ICD-10 procedure codes for surgery: not listed in this table CPT codes: 27187, 27235, 27236, 27244, 27245, 27248, 27269, 27495, 27506, 27507, 27509, 27511, 27513, 27514, 23615, 23616, 23630, 24498, 24515, 24516, 24538, 24545, 24546, 24566, 24575, 24579, 24582, 24586, 24587, 24635, 24665, 24666, 24685, 25490, 25491, 25492, 25515, 25525, 25526, 25545, 25606, 25607, 25608, 25609, 27535, 27536, 27745, 27756, 27758, 27759, 27766, 27769, 27784, 27792, 27826, 27827, 22325, 22326, 22327, 22328, 22520, 22521, 22522, 22532, 22533, 22534, 22548, 22550, 22554, 22555, 22556, 22558, 22565, 22585, 22590, 22595, 22600, 22610, 22612, 22614, 22615, 22625, 22630, 22632, 20982, 23490, 23515, 23585, 27215, 27216, 27217, 27218, 27226, 27227, 27228, 27524, 27540, 22523, 22524, 22525, 22526, 22527, 25574, and 25,575	1 Part A or 1 Part B indicating any bone surgical procedure

References

[1] R.K. Hernandez, A. Adhia, S.W. Wade, E. O'Connor, J. Arellano, K. Francis, H. Alvrtsyan, R.P. Million, A. Liede, Prevalence of bone metastases and bone-targeting agent use among solid tumor patients in the United States, Clin Epidemiol 7 (2015) 335–345.

[2] V. Chia, K. Cetin, J. Jacobsen, M. Nørgaard, A. Jensen, C. Christiansen, H. Sørensen, The incidence and prognostic significance of bone metastases and skeletal-related events in lung cancer patients: A population-based cohort study in Denmark, J Clin Oncol 28 (suppl) (2010) Abstract e18074.

[3] M. Norgaard, A.O. Jensen, J.B. Jacobsen, K. Cetin, J.P. Fryzek, H.T. Sorensen, Skeletal related events, bone metastasis and survival of prostate cancer: a population based cohort study in Denmark (1999 to 2007), J Urol 184 (1) (2010) 162–167.

[4] M. Yong, A. Jensen, J.B. Jacobsen, M. Norgaard, J.P. Fryzek, H.T. Sorensen, Survival associated with bone metastases and skeletal-related events in breast cancer patients: a population-based cohort study in Denmark (1999-2007), J Clin Oncol 27 (suppl) (2009) Abstract e22210.

[5] E. Terpos, N. Kaneallias, L.A. Moulopoulos, D. Christoulas, A. Koureas, T. Bagratuni, V. Koutoulidis, E. Kastritis, M.A. Dimopoulus, Skeletal-Related Events In Patients With Multiple Myeloma In The Era Of Novel Agents: Low Incidence Of Pathological Fractures After Treatment, 2013. [abstract] Available at: https://ashpublications.org/blood/article/122/21/3090/11606/SkeletalRelated-Events-In-Patients-With-Multiple. Accessed March 16, 2020.

[6] National Cancer Institute, SEER Cancer Stat Facts: Myeloma. 2014. Available at: https://seer.cancer.gov/statfacts/html/mulmy.html. Accessed March 16, 2020.

[7] A. Barlev, X. Song, B. Ivanov, V. Setty, K. Chung, Payer costs for inpatient treatment of pathologic fracture, surgery to bone, and spinal cord compression

among patients with multiple myeloma or bone metastasis secondary to prostate or breast cancer, J Manag Care Pharm 16 (9) (2010) 693–702.
[8] M. Hagiwara, T.E. Delea, K. Chung, Healthcare costs associated with skeletal-related events in breast cancer patients with bone metastases, J Med Econ 17 (3) (2014) 223–230.
[9] M. Hagiwara, T.E. Delea, M.W. Saville, K. Chung, Healthcare utilization and costs associated with skeletal-related events in prostate cancer patients with bone metastases, Prostate Cancer Prostatic Dis 16 (1) (2013) 23–27.
[10] D. Bhowmik, D.M. Hines, M. Intorcia, R.L. Wade, Economic burden of skeletal-related events in patients with multiple myeloma: analysis of US commercial claims database, J Med Econ 21 (6) (2018) 622–628.
[11] E. Nash Smyth, I. Conti, J.E. Wooldridge, L. Bowman, L. Li, D.R. Nelson, D.E. Ball, Frequency of skeletal-related events and associated healthcare resource use and costs in US patients with multiple myeloma, J Med Econ 19 (5) (2016) 477–486.
[12] J.A. McDougall, A. Bansal, B.H. Goulart, J.S. McCune, A. Karnopp, C. Fedorenko, S. Greenlee, A. Valderrama, S.D. Sullivan, S.D. Ramsey, The Clinical and Economic Impacts of Skeletal-Related Events Among Medicare Enrollees With Prostate Cancer Metastatic to Bone, Oncologist 21 (3) (2016) 320–326.
[13] M.L. Svendsen, H. Gammelager, C. Svaerke, M. Yong, V.M. Chia, C.F. Christiansen, J.P. Fryzek, Hospital visits among women with skeletal-related events secondary to breast cancer and bone metastases: a nationwide population-based cohort study in Denmark, Clin Epidemiol 5 (2013) 97–103.
[14] K.E. Ponnusamy, Z. Naseer, M.H. El Dafrawy, L. Okafor, C. Alexander, R.S. Sterling, H.S. Khanuja, R.L. Skolasky, Post-Discharge Care Duration, Charges, and Outcomes Among Medicare Patients After Primary Total Hip and Knee Arthroplasty, J Bone Joint Surg Am 99 (11) (2017) e55.
[15] R.M. Werner, R.T. Konetzka, Trends in Post-Acute Care Use Among Medicare Beneficiaries: 2000 to 2015, JAMA 319 (15) (2018) 1616–1617.
[16] S. Li, Y. Peng, E.D. Weinhandl, A.H. Blaes, K. Cetin, V.M. Chia, S. Stryker, J.J. Pinzone, J.F. Acquavella, T.J. Arneson, Estimated number of prevalent cases of metastatic bone disease in the US adult population, Clin Epidemiol 4 (2012) 87–93.
[17] N. Princic, C. Gregory, T. Willson, M. Mahue, D. Felici, W. Werther, G. Lenhart, K.A. Foley, Development and validation of an slgorithm to identify patients with multiple myeloma using sdministrative claims data, Front Oncol 6 (2016) 224.
[18] A. Aly, E. Onukwugha, C. Woods, C.D. Mullins, Y. Kwok, Y. Qian, J. Arellano, A. Balakumaran, A. Hussain, Measurement of skeletal related events in SEER-Medicare: a comparison of claims-based methods, BMC. Med. Res. Methodol 15 (2015) 65.
[19] Centers for Medicaid & Medicare Services. Patient Discharge Status Codes Matter. Available at: https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/Fast-Facts/Patient-Discharge-Status-Codes-Matter.html. Accessed March 16, 2020.
[20] Skloff Financial Group. Cost of long-term care by state. Available at: http://skloff.com/cost-of-long-term-care-by-state-2015/. Accesssed March 16, 2020.
[21] Medicare Payment Advisory Committee. Report to the Congress: Medicare Payment Policy 2019: Skilled nursing facility services. Available at: http://medpac.gov/docs/default-source/reports/mar19_medpac_ch8_sec.pdf. Accesssed March 16, 2020.
[22] Medicare Payment Advisory Committee. Health Care Spending and the Medicare Program, June 2017. Available at: http://medpac.gov/docs/default-source/data-book/jun17_databookentirereport_sec.pdf. Accesssed March 16, 2020.
[23] Centers for Medicare & Medicaid Servicdes. Medicare utilization and payment. Available at: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/CMSProgramStatistics/2015/2015_Utilization. Accesssed March 16, 2020.
[24] E.R. Berchick, E. Hood, J.C. Barnett, Health Insurance Coverage in the United States: 2017. In: Current Population Reports, 2017., Washington, DC, 2018, 2018. Available at: https://www.census.gov/content/dam/Census/library/publications/2018/demo/p60-264.pdf. Accessed on March 16, 2020.