OPEN ACCESS

GAVIN PUBLISHERS

International Journal of Musculoskeletal Disorders

Research Article

Sundaram K, et al. Int J Musculoskelet Disord: IJMD-107
DOI: 10.29011/ IJMD-107. 000007

Hip Fracture Admissions Among Medicare Beneficiaries 2010-2015 -Rising Hospital Costs and Falling Reimbursements

Kavin Sundaram[1*], Steven Culler[1], April Simon[3], David S. Jevsevar[1,2], I. Leah Gitajn[1], Michael J Schlosser[5]

[1]The Geisel School of Medicine at Dartmouth, Dartmouth-Hitchcock Medical Center,1 Medical Center Drive, Lebanon, NH, USA

[2]Emory School of Public Health, Atlanta, GA, USA

[3]Cardiac Data Solutions, GA, USA

[4]HealthTrust PCG, Brentwood, Tennessee, USA

[*]**Corresponding author:** Kavin Sundaram, Department of Orthopaedics, The Geisel School of Medicine at Dartmouth, Dartmouth-Hitchcock Medical Center,1 Medical Center Drive, Lebanon, NH, USA. Tel: +16036536014; Fax: +16036533581; Email: Kavin.sundaram.med@dartmouth.edu

Citation: Sundaram K, Culler S, Simon A, Jevsevar DS, Gitajn IL, et al. (2018) Hip Fracture Admissions among Medicare Beneficiaries 2010-2015-Rising hospital costs and falling reimbursements. Int J Musculoskelet Disord: IJMD-107 DOI: 10.29011/ IJMD-107. 000007

Received Date: 28 June, 2018; **Accepted Date:** 29 October, 2018; **Published Date:** 6 October, 2018

Abstract

Background: This paper reports trends in care and costs associated with hip fracture admissions among Medicare Beneficiaries (MB).

Methods: This retrospective study identified 1,558,428 primary hip fracture admissions using the Medicare Provider Analysis and Review Files from fiscal years 2010 through fiscal year 2015.

Results: The total number of admissions rose from 246,825 to 276,659; however, rate per 1000 MB was 4.96 in 2010 and 4.98 in 2015. In all years, the patients were mostly female, Caucasian, and over age 80. Patient complexity increased as evidenced by greater comorbidity reporting. Most patients received an Open Reduction and Internal Fixation (ORIF) or partial hip arthroplasty, although there was a slight decline in partial hip arthroplasty and concurrent rise in total hip replacement. The cost per patient rose from $12,363 to $14093 ($p<0.0001$) despite a fall in average LOS from 5.8 to 5.42 days ($p<0.0001$) and a fall in in-hospital mortality from 2.6% to 2.2%. Reimbursements fell $1,118 from $10,304 in 2010 to $9,186 in 2015.

Conclusions: Average hospital cost per beneficiary rose during our study period while inflation-adjusted reimbursements fell. We found lower average LOS and postop mortality. Rates of AKI on presentation and co-morbid infection have risen. The number of patients receiving THA has risen but the most common treatment is femur repair.

Background

On July 25, 2016, the Department of Health & Human Services (HHS) proposed a new model that expands bundled payments to include Surgical Hip and Femur Fracture Treatment (SHFFT) [1-2]. This progression theoretically shifts Medicare payments from quantity to quality by creating strong incentives for hospitals to deliver better care at a lower cost [3-4]. An estimated 300,000 Medicare beneficiaries suffer a hip fracture per year [5]. In 2014, an average of 5.8 beneficiaries per 1,000 suffered a hip fracture [6]. The primary objective of this study is to report on trends associated with MBs admitted to US hospitals with a primary diagnosis of hip fracture from fiscal years 2010 through fiscal year 2015. We report outcomes among patients receiving Total Hip Arthroplasty (THA), Partial Hip Arthroplasty (PH), femur repair, and non-operative care. We predicted higher prevalence of baseline comorbidities, higher costs, and lower reimbursements due to national policies favoring cost settings in the setting of an increasingly older US population.

Methods

Data Source

Center for Medicare and Medicaid Services maintains a database called Med PAR that contains all submitted claims for services provided to MBs. We obtained a data set from this database that spanned from 2010 to 2015.

Study Population Selection

100% of Medicare Part A and C claims were included. During the study period CMS required claims for every hospitalization ensuring there were no missing claims from part C. Individuals under age 65 may be eligible for Medicare due to disabilities. After careful consideration, we decided to include this population based on prior literature that demonstrated that most patients 40-50 years share a common mechanism with patients over 65-osteoporotic fragility fractures with a fall as an inciting event [7]. Furthermore, prior work from the Kaiser-Family foundation found that a similar proportion of MBs under-65 versus over-65 have 5 or more medical conditions (31% versus 28% percent) suggesting a similar burden of comorbid disease [8]. Patients under 65 eligible for Medicare due to end-stage renal disease were included due to constraints of our data set but prior research suggests they constitute less than 1% of the total Medicare Population [9-10].

The Med Par dataset includes basic demographic information, up to 25 diagnostic ICD-9-CM codes with Present on Admission (POA) flags, primary procedure code, up to 24 additional ICD-9-CM procedures codes, LOS in days, discharge status (discharge disposition or site), total charges, and total reimbursement from the Medicare program. We identified patients using ICD-9 codes after careful consideration of prior literature. Data support the use of "fracture of the neck of Femur" relative to chart review (PPV=0.85-0.93) [11-14]. While "pathological fractures" most commonly refer to osteoporotic fragility fractures some clinicians may use the code for patients with metastatic disease. Prior studies have shown a very low rate of metastasis related oncologic fracture in the Medicare population (0.3 patients per 1,000 MB) and the risk of false negatives when excluding "pathologic fracture", we elected to use ICD-9 code 733.14 for pathological fracture of the neck of the femur [15-16]. Codes of for atypical femur fractures had low sensitivity for extra-capsular fractures and rates of mid-shaft and distal femur fractures are low in an elderly population, so we included the ICD-9 code for pathological fracture of other specified part of the femur. Ultimately we searched for patients who had any of the following 3 codes in any of the diagnostic positions in the database.

- Fracture of the neck of Femur (ICD-9 Code 820)
- Pathologic fracture of neck of femur (ICD-9 code 733.14)
- Pathologic fracture of other specified part of femur (ICD-9 733.15)

A total of 1,558,428 Medicare beneficiaries were in the final study population. The observation period for diagnoses for each patient began on admission and ended on discharge.

Operational Definitions and Analysis

Medicare Reimbursement

Was defined strictly as the Medicare payment for each hospitalization. This does not include any out-of-pocket payments by MBs or secondary payers. The cost of each hospitalization was estimated by multiplying total billed charges by the hospital-level cost-to-charge ratio obtained from the appropriate hospital's Annual Medicare Cost Report (or the most recent settled cost report of the hospital). Length-of-Stay (LOS) was defined as the whole number of days from admission to discharge. Our treatment groups included total-hip arthroplasty (THA), Partial Hip Arthroplasty (PHA), femur repair, and non-operative treatment. Claims were evaluated using both Part A and Part C.

Statistical Analysis

A two sided chi-square test assessed the presence or absence statistically of significant univariate trends over the study period. Subsequent one-sided analyses tested the presence or absence of a trend with a positively skewed tail or a negatively skewed tail. Trends were statistically different if the P value was less than or equal to 0.01. Organizational variables analyzed include estimated hospital costs, Medicare reimbursements, length of stay, and discharge status. Clinical variables included type of operative treatment, adverse events, and mortality. All analyses were performed with SAS 9.3 (SAS Institute, Cary, North Carolina).

Approval and Funding

Our study received evaluation and approval from the Dartmouth-Hitchcock IRB as an exempt study. Funding did not play a role in our study.

Results

The final study population included a total of 1,558,428 Medicare beneficiaries over 6 years. (Figure 1) describes the number of beneficiaries treated by year. The total number of MBs experiencing a primary hip fracture has increased from 246,825 in FY-2010 to 276,659 in FY-2015. (Figure 1), Compounded Annual Growth Rate=2.8%). The rate of fractures per 1000 MB was 4.96 in 2010 versus 4.98 in 2015. (Figure 2)

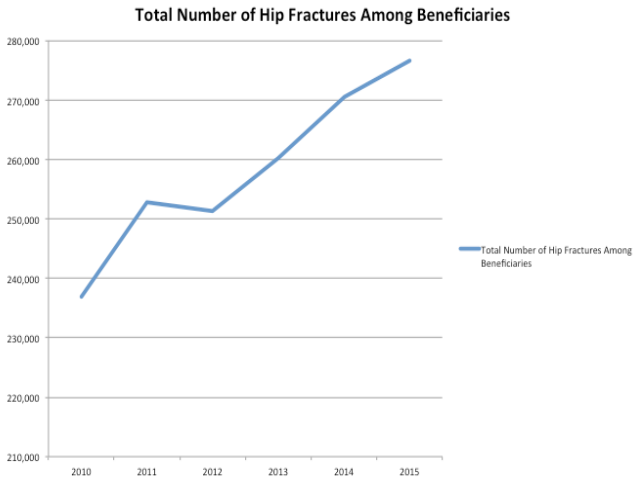

Figure 1: Absolute Annual Rate of Hip Fractures among Medicare Beneficiaries.

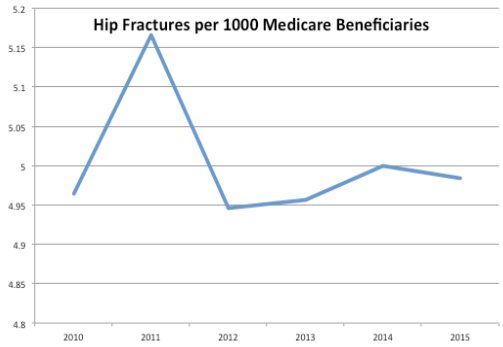

Figure 2: Annual Rate of Hip Fractures per 1,000 Medicare Beneficiaries.

In 2015, women constituted 70.5% of our population. 64.2% of patients had reached age 80 or greater and Caucasians represented 91.4% of the population. Each of these variables experienced a statistically significant fall ($p \leq 0.001$, Table 1); however, none of the listed demographic changes declined by more than 2%.

Variable	2010[a]	2011[a]	2012[a]	2013[a]	2014[a]	2015[a]	p-Value[b]
Age (years)							
Less than 65	4.0%	4.1%	4.3%	4.4%	4.4%	4.5%	p≤0.001
65 to 69	6.9%	7.2%	7.4%	7.5%	8.1%	8.3%	p≤0.001
70 to 79	21.8%	21.9%	21.9%	22.2%	22.8%	23.0%	p≤0.001
80 or greater	67.4%	66.8%	66.5%	66.0%	64.8%	64.2%	p≤0.001
Gender							
Female	72.1%	71.6%	72.0%	71.4%	70.7%	70.5%	p≤0.001
Race							
White	92.1%	92.0%	91.7%	91.7%	91.5%	91.4%	p≤0.001
Black	4.0%	3.9%	4.1%	4.0%	4.1%	4.1%	p=0.007
Hispanic	1.6%	1.6%	1.6%	1.7%	1.6%	1.6%	p=0.564
All others	2.4%	2.5%	2.6%	2.6%	2.8%	2.9%	p≤0.001
[a]all rows expressed as patients with variable divided by total beneficiaries diagnosed with hip fracture in a given year. [b] p-value represent the result of a chi-squared test comparing changes between 2010 and 2015.							

Table 1: Demographic Characteristics.

In contrast to demographic characteristics-which remained largely-the prevalence of several medical morbidities rose dramatically. (Table 2) There was a statistically significant rise in several of the most common cardiovascular comorbidities include hypertension (60.75% to 75.30%), chronic ischemic heart disease (18.73% to 25.55%), atrial fibrillation (17.91% to 23.54%), congestive heart failure (14.74% to 16.68%). ($p \leq 0.001$, Table 2) Type II diabetes and Osteoporosis were common endocrine abnormalities with a statistically significant from 17.91% to 22.72% and 10.20% to 16.23% respectively. ($p \leq 0.001$, Table 2).

Long-term use of anticoagulation	2.88%	6.96%	8.26%	8.74%	9.05%	9.49%	p≤0.001	6.61%
Atrial fibrillation POA	16.81%	20.68%	22.04%	22.42%	22.90%	23.54%	p≤0.001	6.73%
Prior PE	0.00%	0.00%	1.07%	1.49%	1.66%	1.80%	p≤0.001	1.80%
Prior VTE	1.54%	3.44%	3.68%	3.67%	3.60%	3.83%	p≤0.001	2.29%
Anemia POA	3.36%	3.54%	3.82%	3.90%	4.07%	4.00%	p≤0.001	0.64%
Hypertension	60.75%	70.24%	73.79%	74.24%	74.64%	75.30%	p≤0.001	14.55%
Prior coronary revascularization	6.98%	14.47%	16.94%	17.35%	17.41%	17.41%	p≤0.001	10.43%
Prior CVA	4.04%	8.70%	10.30%	10.60%	10.91%	11.12%	p≤0.001	7.08%
Chronic ischemic heart disease	18.73%	24.91%	26.35%	25.90%	25.70%	25.55%	p≤0.001	6.82%
Atrial fibrillation POA	16.81%	20.68%	22.04%	22.42%	22.90%	23.54%	p≤0.001	6.73%
Prior myocardial infarction	3.48%	6.25%	6.95%	6.97%	7.06%	7.19%	p≤0.001	3.71%
Congestive heart failure	14.74%	16.30%	16.66%	16.38%	16.33%	16.68%	p≤0.001	1.94%
Peripheral vascular disease	0.68%	1.23%	1.53%	1.81%	1.98%	2.05%	p≤0.001	1.37%
Long-term use of Aspirin	2.34%	7.63%	10.42%	11.54%	12.80%	14.50%	p≤0.001	12.16%
Long-term use of antiplatelet	0.47%	1.82%	2.46%	2.47%	2.55%	2.68%	p≤0.001	2.21%

History of Smoking	3.09%	8.77%	11.81%	13.61%	15.93%	18.40%	p≤0.001	
Diabetes Type II	17.91%	21.15%	22.25%	22.42%	22.50%	22.72%	p≤0.001	4.81%
Body mass index greater than 30	0.53%	1.13%	1.61%	2.02%	2.44%	2.92%	p≤0.001	2.39%
Obesity	1.49%	2.77%	3.38%	3.69%	3.79%	4.32%	p≤0.001	2.83%
Body mass index less than 19	1.60%	1.87%	2.19%	2.47%	2.79%	3.07%	p≤0.001	1.47%
Malnutrition	4.49%	5.37%	5.66%	5.69%	5.60%	5.88%	p≤0.001	1.39%
Chronic kidney disease	11.66%	16.04%	17.89%	18.41%	19.25%	19.88%	p≤0.001	8.22%
Acute renal failure POA	4.34%	4.68%	5.31%	5.73%	6.30%	6.84%	p≤0.001	2.50%
COPD	2.74%	3.14%	3.11%	3.13%	3.07%	3.19%	p≤0.001	0.45%
Smoker	4.71%	7.33%	8.26%	8.67%	9.06%	9.54%	p≤0.001	4.83%
Osteoporosis	10.20%	15.17%	16.55%	16.43%	16.21%	16.23%	p≤0.001	6.03%
Prior TKA	1.67%	3.65%	4.45%	4.64%	4.89%	5.29%	p≤0.001	3.62%
Prior THA	1.96%	3.57%	4.27%	4.45%	4.70%	5.08%	p≤0.001	3.12%

Table 2: Comorbidities Among Medicare Beneficiaries Who Experienced a Hip Fracture: 2010 To 2015.

The number of smokers doubled from 4.71% to 8.54%; history of smoking increased from 3.09% to 18.40%. Prior myocardial infarction doubled from 3.48% to 7.19%, prior cva nearly tripled from 4.04% to 11.12%. Long-term anticoagulation rose from 2.88% to 9.49%, long-term aspirin use rose from 2.34% to 14.50%. Patients with prior THA doubled from 1.96% to 5.08%; prior TKA tripled from 1.67 to 5.08%. History of prior pathological fractures tripled from 0.10% to 0.36% and prior traumatic fractures rose from 0.19% to 0.76%. (Table 3) documents the procedural treatment of these patients. The proportion of patients receiving primary femur repair remain unchanged (50.8% to 50.9%, p=0.651). Fewer patients received partial hip replacement (32.2% to 30.5%, p≤0.001); the number of total hip replacements rose from 3.0% to 4.2% (p≤0.001).

Procedures	2010	2011	2012	2013	2014	2015	Change	p-Value, trend
Hip Replacement	3.0%	3.3%	3.5%	3.8%	4.1%	4.2%	1.20%	p≤0.001
Partial Hip Replacement	32.2%	31.7%	31.3%	31.2%	30.8%	30.5%	-1.70%	p≤0.001
Femur Repair	50.8%	50.8%	50.8%	50.9%	50.7%	50.9%	0.10%	p=0.651

Table 3: Operative Treatment Performed on MB during Primary Hip Fracture Admission.

Hospital LOS declined slightly (5.8 to 5.42, p≤0.001). The reimbursements in 2010 was $10, 304 and in 2015 it was $9816 when adjusted for inflation. Hospitals reported average cost per beneficiary of $12,363 and it was $14093 in 2015 when adjusted for inflation and expressed in 2010 US Real dollars. (Table 4).

	2010	2011	2012	2013	2014	2015
LOS	5.80 [5.78 -5.82]	5.72*** [5.70-5.74]	5.61*** [5.59-5.63]	5.54*** [5.52-5.56]	5.43*** [5.41-5.45]	5.42*** [5.40-5.44]
Cost	$12,363 [11,592-13,134]	$13,306 [10255-13198]	$15,149*** [10,346-14,064]	$15,214*** [14,194-16,234]	$16,010*** [14,944-17,077]	$15,321*** [14,261-16,383]
Medicare Reimbursement	$10,304 [10,271-10,337]	$10,255 [10,209-10,301]	$10,346 [10,300-10,392]	$10,365 [10,320-10,411]	$10,226*** [10,181-10,271]	9,987*** [9942-10,032]
Note: ***The p-value ≤ 0.001 for each given year compared to 2010. Value estimated coefficient on the variable indicating specific year had an estimated p-value.						

Table 4: Hospital Resources Consumed by MB during Hip Fracture Admission Mean [95% Confidence Intervals], *** p-value ≤ 0.001.

In 2015, renal failure on presentation was more common than comorbid VTE, infection, and CHF combined. Rates of renal failure on admission and all types of infection rose while postop CHF and VTE fell. (Table 5). In-hospital mortality and 180-day mortality fell, but only the fall in in-hospital mortality was statistically significant (Table 6).

Year	CPI-U-RS		2010 m	2010 ci-l	2010 ci-u	2011 m	2011 ci l	2011 u	2012 m	2012 ci l	2012 ci u	2013 m	2013 ci l	2013 u	2014 m	2014 ci l	2014 ci u	2015 m	2015 ci l	2015 u
2010		Cost	12363	11592	13134	13306	11780	14831	15149	13948	16349	15214	14192	16234	16010	14922	17077	15321	14261	16383
2011		2010 dollars	12363	11592	13134	12895	11416	14373	14385	13245	15525	14240	13284	15195	14744	13742	15727	14093	13118	15070
2012																				
2013																				
2014																				
2015																				
2016																				

Year	CPI-U-RS		2010 m	2010 ci -l	2010 ci-u	2011 m	2011 ci l	2011 u	2012 m	2012 ci l	2012 ci u	2013 m	2013 ci l	2013 u	2014 m	2014 ci l	2014 ci u	2015 m	2015 ci l	2015 u
2010		Reimbursement																		
2011		2010 dollars																		
2012																				
2013																				
2014																				
2015																				
2016																				

Table 5: All types of infection rose while postop CHF and VTE fell.

In-Hospital						
		All Groups	Non-operative	Femur Repair	Partial Hip Arthroplasty	Total Hip Arthroplasty
	2010	2.60%	5.41%	2.05%	2.31%	1.71%
	2015	2.2	4.23%	1.82%	1.88%	1.11%
	Average		4.75%	1.91%	2.09%	1.32%
	Change	-0.40%	-1.05	-0.13	-0.43%	-0.60%
	Ptrend	p≤0.01	p≤0.01	p≤0.01	p≤0.001	p=0.001
30 days						
		All Groups	Non-operative	Femur Repair	Partial Hip Arthroplasty	Total Hip Arthroplasty
	2010	6.10%	9.96%	5.47%	5.72%	3.13%
	2015	6.4	10.81%	5.60%	6.15%	2.62%
	Average		10.38%	5.50%	5.92%	2.91%
	Change	0.30%	0.50%	0.13%	0.43	-0.41%
	Ptrend	p≤0.001	p=0.006	p=0.009	p=0.006	p=0.040
90-Days						
		All Groups	Non-operative	Femur Repair	Partial Hip Arthroplasty	Total Hip Arthroplasty

	2010	12.50%	16.74%	11.77%	12.33%	7.27%
	2015	12.8	17.63%	11.84%	13.01%	5.67%
	Average		17.16%	11.72%	12.65%	6.46%
	Change	0.30%	-0.11%	0.07%	0.65%	-1.60%
	Ptrend	p=0.004	p=0.026	p≤0.001	p≤0.001	p≤0.001
180 Day mortality						
		All Groups	Non-operative	Femur Repair	Partial Hip Arthroplasty	Total Hip Arthroplasty
	2010	20.40%	27.93%	19.01%	19.94%	12.86%
	2015	20.1	27.55%	18.70%	20.73%	9.67%
	Average		27.68%	18.73%	20.02%	11.02%
	Change	0.30%	-0.38	-0.31%	0.79%	-3.19
	Ptrend	p=0.063	p=0.028	p=0.006	p=0.003	p≤0.001

Table 6: In-hospital mortality and 180-day mortality fell, but only the fall in in-hospital mortality was statistically significant.

Discussion

Our analysis of over 1.5 million MBs who constitute 100% of the patients receiving coverage for a hospital admission associated with hip fracture showed that 4.98 beneficiaries per 1,000 suffered a hip fracture in 2015. During this period, the prevalence of several comorbidities rose including AKI, infection, and anemia. These findings are likely clinically significant because risk stratification models predict worse outcomes with greater prevalence of co-morbidities[17] or example, the rise in comorbid infections is noteworthy because chest infections stand as one of the leading causes of death at 180 days [18]. Future research is needed to investigate this finding.

Our study shows rising rates of treatment with hip arthroplasty. This is congruent with prior literature that has favored THA, particularly for displaced fractures, though specific indications for specific patients remain an area of continued research [19]. During our study period, the average cost per patient rose. Reimbursements fell after adjustment for inflation.

This study does have some limitations that we have carefully considered. Our retrospective review documented comorbidities documented on admission or during a patient's length of stay. As our data set did not include a look-back period, we could only determine the timing of diagnoses "on admission." Future research may provide further clarity in this area that may be particularly important for patients with infections and kidney injury.

We reviewed the literature regarding the performance of ICD-10 and ICD-9 in administrative databases compared to chart. Multiple studies have reported a PPV ranging from 0.85 to 0.93 when for using ICD-9 codes when searching for hip fractures [12-14]. These studies supported the accuracy of PE recording (sensitivity=0.91, PPV= 0.823, and NPV=0.999) [20-22]. Rates of DVT are confounded by absence of imaging or proper documentation. These studies support the validity of our finding that the rate of AKI rose on admission with possible bias of under-reporting and no changes in the rate of coding diagnoses [24-25]. Anemia data often have high NPV but suffer from under-reporting (PPV=0.12-0.20); however, prior studies generally support the validity of our findings with PPV and NPV values and caution against under-reporting of most comorbidities and complications we reviewed [26-29].

Patients under 65, with or without end-stage renal disease, may have different characteristics than patients over 65 with osteoporotic fragility fractures. Future research may investigate these populations specifically and compare their clinical outcomes and hospital costs to patients over 65. Future research may also examine factors affecting care of MBs with hip fractures due to metastatic disease. Prior literature provides targets for reducing cost. Preventive osteoporosis care remains underutilized based on prior studies and our data suggest a rising prevalence [30-31]. Expedited care has improved outcomes and reduced costs [32]. Optimization of pre-hospital fluid resuscitation may represent a future area of [33]. Judicious selection of preoperative tests may represent another area for improvement. Studies of pre-operative workup suggests clinical laboratory testing may provide relevant information, particularly PT and PTT [33]. On the other hand, as many as 34% of patients still get a TTE when they do not meet ACA/AHA criteria which may significantly elevate costs [34-35]. Clinical literature has supported use of Arthroplasty for treatment of displaced fractures. The cost of associated implants has risen; however, several hospitals have instituted policies that allow cost control while preserving surgeon autonomy [36-38].

Preventing even common complications may be both medically relevant and financially impactful. In prior work in total knee arthroplasty patients, we demonstrated how common complications such as AKI and bleeding requiring transfusion could add to costs of hospitalization [39]. Studies have shown pneumonia and surgical site infections can dramatically raise in-hospital costs and we found these conditions rose during our study period [40]. Future research can define outcomes at 1-2 year or gender differences. Ortho Care, a successful bundled pay system in Sweden, does not cover rehabilitation but other models do include bundles for rehabilitation [41]. Research on discharge status can provide more information on ideal post-operative care and optimal delivery of such care. A body of literature has accumulated to support the use of bundled payment programs to promote efficient systems that provide evidence-based care [42-43].

Conclusions

Our study reports trends in a data set that captures 100% Medicare Part A and C beneficiaries treated from 2010 to 2015 with a hip fracture associated admission. The absolute number of MBs admitted with a hip fracture diagnosis rose from 2010 to 2015, but the rate per 1,000 MB was 4.96 in 2010 versus 4.98 in 2015. The prevalence of comorbidities rose during our study period. MBs had lower in-hospital mortality. Average cost rose and lower average LOS fell. Surgeons used THA at a rising rate but femur repair is the most common treatment.

References

1. Medicare Program; Comprehensive Care for Joint Replacement Payment Model for Acute Care Hospitals Furnishing Lower Extremity Joint Replacement Services; Corrections and Correcting Amendments. Federal Register (2016).
2. Medicare C, Baltimore MS, Usa SB (2016) Notice of proposed rule-making for bundled payment models for high-quality. coordinated cardiac and hip fracture care.
3. Dummit LA, Kahvecioglu D, Marrufo G, Rajkumar R, Marshall J, et al. (2016) Association Between Hospital Participation in a Medicare Bundled Payment Initiative and Payments and Quality Outcomes for Lower Extremity Joint Replacement Episodes. JAMA 316: 1267-1278.
4. Fisher ES (2016) Medicare's Bundled Payment Program for Joint Replacement: Promise and Peril? JAMA 316: 1262-1264.
5. HCUPnet. Healthcare Cost and Utilization Project (HCUP) (2012) Agency for Healthcare Research and Quality. Rockville MD.
6. The Dartmouth Atlas (2017) The Dartmouth Institute for Healthcare Policy.
7. Robinson CM, Court-Brown CM, McQueen MM, Christie J, et al. (1995) Hip fractures in adult younger than 50 years of age. Epidemiology and results. Clin Orthop Res 312: 238-246.
8. Cubanski, J Neuman T, Damico A (2010) Medicare's role for people under Age 65 with disabilities. Kaiser-Family Foundation.
9. Arneson, TJ, Am J Kidney D (2013) Trends in hip fracture rates in US hemodialysis patients, 1993-2010.
10. Quan H, Li B, Saunders LD, Parsons GA, Nilsson CI, et al. (2008) Assessing Validity of ICD-9-CM and ICD-10 Administrative Data in Recording Clinical Conditions in a Unique Dually Coded Database. Health Services Research 43: 1424-1441.
11. Hudson M, Zubieta AA, Lacaille D, Bernatsky S, Lix L, et al. (2013) The validity of administrative data to identify hip fractures is high--a systematic review. J Clin Epidemiol 66: 278-285.
12. Narongroeknawin P, Patkar NM, Shakoory B, Jain A, Curtis JR, et al. (2012) Validation of diagnostic codes for subtrochanteric, diaphyseal, and atypical femoral fractures using administrative claims data. J Clin Densitom 15: 92-102.
13. Sing CW, Woo YC, Lee ACH, Lam JKY, Chu JKP, et al. (2017) Validity of major osteoporotic fracture diagnosis codes in the Clinical Data Analysis and Reporting System in Hong Kong. Pharmacoepidemiol Drug Saf 26: 973-976.
14. Shuling, Li, Peng Y, Weinhandl ED, Blaes AH, Cetin K, et al. (2012) Estimated number of prevalent cases of metastatic bone disease in the US adult population. Clin Epidemiol 4: 87-93.
15. Kirollos G, Hennessy D, Heiner J (2016) The burden of metastatic disease of the femur on the Medicare system. Springerplus 5: 1916.
16. Roche JW (2005) Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study.
17. Abrahamsen B, van Staa T, Ariely R, Olson M, Cooper C, et al. (2009) Excess mortality following hip fracture: a systematic epidemiological review. Osteoporos Int 20: 1633-1650.
18. Butler M, Forte ML, Joglekar SB, Swiontkowski MF, Kane RL, et al. (2011) Evidence Summary: Systematic Review of Surgical Treatments for Geriatric Hip Fractures. J Bone Joint Surg Am 93: 1104-1115.
19. DiGiovanni MD Lubberts B, Vopat BG, Johnson AH, Guss D, et al. (2016) The Validity of Using ICD-9 Codes for Identifying Venous Thromboembolism Following Below Knee Surgery. The orthopaedic journal at harvard medical school 17.
20. Di Giovanni MD (2016) The Validity of Using ICD-9 Codes for Identifying Venous Thromboembolism Following Below Knee Surgery. The Orthopaedic Journal At Harvard Medical School 17.
21. Burles K, Innes G, Senior K, Lang E, McRae A, et al. (2017) Limitations of pulmonary embolism ICD-10 codes in emergency department administrative data: let the buyer beware. BMC Med Res Methodol 17: 89.
22. Casez P, Labarère J, Sevestre MA, Haddouche M, Courtois X, et al. (2010) ICD-10 hospital discharge diagnosis codes were sensitive for identifying pulmonary embolism but not deep vein thrombosis. J Clin Epidemiol 63: 790-977.
23. Tomson CR, Riding AM, Payne RA, Abel GA, Tomson CR, et al. (2013) The accuracy of diagnostic coding for acute kidney injury in England-a single centre study. BMC Nephrology 14: 58.
24. Morgan EG, Plantinga LC, Hedgeman E, Saran R, Myers GL, et. al. (2011) Validation of CKD and Related Conditions in Existing Datasets: A Systematic Review. Am J Kidney Dis 57: 44-54.
25. McCormick N (2014) Validity of Heart Failure Diagnoses in Administra-

tive Databases: A Systematic Review and Meta-Analysis. Plos One 9.

26. Tomlinson LA, Hjerpe P, Merlo J, Ohlsson H, Bengtsson Boström K, et al. (2010) Validity of registration of ICD codes and prescriptions in a research database in Swedish primary care: a cross-sectional study in Skaraborg primary care database. BMC Medical Informatics and Decision Making 10: 23.

27. McCormick N, Lacaille D, Bhole V, Avina-Zubieta JA (2014) Validity of Myocardial Infarction Diagnoses in Administrative Databases: A Systematic Review PLoS ONE 9.

28. McCormick N (2015) Validity of Diagnostic Codes for Acute Stroke in Administrative Databases: A Systematic Review. PLoS ONE 10.

29. Giannoulis, D (2016) Thirty-day mortality after hip fractures: has anything changed? Eur J Orthop Surg Traumatol 26: 365-370.

30. Sander B, Elliot-Gibson V, Beaton DE, Bogoch ER, Maetzel A. et al. (2008) A Coordinator Program in Post-Fracture Osteoporosis Management Improves Outcomes and Saves Costs." J Bone Joint Surg Am 90:1197-1205.

31. Kate SL (2011) The Value of an Organized Fracture Program for the Elderly: Early Results. J Orthop Trauma 25: 233-237.

32. Christopher JD (2011) An Economic Evaluation of a Systems-Based Strategy to Expedite Surgical Treatment of Hip Fractures. J Bone Joint Surg Am 93: 1326-1334.

33. N Lakomkin, Sathiyakumar V, Dodd AC, Jahangir AA, Whiting PS, et al. Pre-operative labs: Wasted dollars or predictors of post-operative cardiac and septic events in orthopaedic trauma patients? Injury Int. J. Care Injured 47: 1217-1221.

34. Adair C, Swart E, Seymour R, Patt J, Karunakar MA, et al. (2017) Clinical Practice Guidelines Decrease Unnecessary Echocardiograms Before Hip Fracture Surgery. J Bone Joint Surg Am. 99: 676-80.

35. Stitgen A, Poludnianyk K, Dulaney-Cripe E, Markert R, Prayson M, et al. (2015) Adherence to Preoperative Cardiac Clearance Guidelines in Hip Fracture Patients." Orthop Trauma 29: 500-503.

36. Belatti DA, Pugely AJ, Phisitkul P, Amendola A, Callaghan JJ, et al. (2014) Total Joint Arthroplasty: Trends in Medicare Reimbursement and Implant Prices. Total Joint Arthroplasty: Trends in Medicare Reimbursement and Implant Prices. The Journal of Arthroplasty 29: 1539-1544.

37. Healy WL, Iorio R, Lemos MJ, Patch DA, Pfeifer BA, et al. (2000) Single Price/Case Price Purchasing in orthopaedic surgery: experience at the Lahey Clinic. The Journal of Bone and Joint Surgery. American Volume. 82: 607-612.

38. Okike K (2017) "Red-Yellow-Green": Effect of an Initiative to Guide Surgeon Choice of Orthopaedic Implants. J Bone Joint Surg Am 99.

39. Culler SD, Jevsevar DS, Shea KG, Wright KK, Simon AW, et al. (2015) The Incremental Hospital Cost and Length-of-Stay Associated with Treating Adverse Events Among Medicare Beneficiaries Undergoing TKA. The Journal of Arthroplasty 30: 19-25.

40. Van Walraven C (2013) The Surgical Site Infection Risk Score (SSIRS): A Model to Predict the Risk of Surgical Site Infections. PLoS ONE 8.

41. Porter ME (2014) OrthoChoice: Bundled Payments in the County of Stockholm. Harvard Business School.

42. Siddiqi A, White PB, Mistry JB, Gwam CU, Nace J, et al. (2017) Effect of Bundled Payments and Health Care Reform as Alternative Payment Models in Total Joint Arthroplasty: A Clinical Review The Journal of Arthroplasty 32: 2590-2597.

43. Navathe AS, Troxel AB, Liao JM, Nan N, Zhu J, et al. (2017) Cost of Joint Replacement Using Bundled Payment Models" JAMA Intern Med 177: 214-222.