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Research Article

Impact of Pacemaker Implantation on 12-Month Resource Utilization Following TAVR Hospitalization

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Abstract

Purpose: This study reports resource utilization during a Medicare Beneficiary's (MBs) Transcatheter Aortic Valve Replacement (TAVR) index hospitalization and all subsequent encounters for 12 months and compares data between MBs who did or did not receive a pacemaker implantation (PPM) during their index hospitalization.

Method: This retrospective study examined Medicare hospital claims from January 1, 2014 through June 30, 2015. 15,533 MBs who survived for 365 days were studied. Information from all encounters during the study period was combined to compare hospital resource utilization and outcomes.

Results: 14.8% of MBs had a PPM during the index hospitalization. 46.0% of MBs had at least one readmission to a hospital during the 365-day follow-up period. 54.6% of MB's first hospital readmission occurred within 90 days of their TAVR discharge date. Average total Medicare reimbursement for all hospitalizations was $60,638 ± $28,974 associated with average total hospital length of stay of 11.2 ± 11.7 days. After adjusting for demographics and 47 comorbid conditions, MBs receiving a PPM during the index TAVR had significantly higher estimated Medicare reimbursement ($5,132) and longer total length of stay (1.8 days) for the entire study period than MBs not receiving a PPM.

Conclusion: Total Medicare reimbursement and hospital LOS were significantly higher among MBs that had a PPM implantation during their index admission; however, there were no significant differences in readmission rates, readmission length of stay, or days to first readmission during the follow-up period between the two study cohorts.

More Information

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Keywords: TAVR; Medicare reimbursement Episode of care; Hospital resources

Abbreviations and Acronyms: DRG: Diagnosis Related Group; ICD: Implantation of Vardioverter-Defibrillator; ICD-9-CM: International Classification of Disease, 9th Edition Clinical Modifications; IPSAF: Inpatient Standard Analytical Files; LOS: Length of Stay; MBs: Medicare Beneficiaries; OPSAF: Outpatient Standard Analytical Files; PPM: Pacemaker Implantation; SAVR: Surgical Aortic Valve Replacement; TARV: Transcatheter Aortic Valve Replacement

Introduction

Transcatheter aortic valve replacement (TAVR) offers a less invasive approach than surgical aortic valve replacement (SAVR) to treat severe aortic stenosis in patients with intermediate or high surgical risk from conventional SAVR, or for whom SAVR is contraindicated [1-5]. With similar primary clinical outcomes for TAVR as SAVR in inoperable, high and intermediate risk patients, there has been a sharp rise in the number of TAVR procedures being performed [4,6,7], especially among Medicare Beneficiaries (MBs) [8].

TAVR's cost effectiveness and value in high risk patients has been evaluated [9-12]. Patients with a high risk profile undergoing an index TAVR procedure experience shorter inpatient lengths of stay (LOS) than SAVR, however, procedural costs including the acquisition cost for the transcatheter valve, have resulted in higher index hospital costs [12]. Periprocedural complications experienced during an index TAVR hospitalization have been described, and impact TAVR's effective cost [11].

An important clinical complication associated with TAVR

is atrioventricular conduction disturbance that requires permanent pacemaker implantation (PPM) [13,14]. PPM following TAVR is associated with higher index hospitalization cost due to both procedural cost and increased LOS [11,14]. In addition; PPM post-TAVR has been reported to increase the risk of unexpected hospital re-admission [13,15,16].

From a hospital's financial risk perspective, the U.S. Centers for Medicare and Medicaid Services has identified cardiac valve procedures for voluntary bundled payment beginning in October 2018 and extending to December 2023 [17]. Reimbursement under a shared risk arrangement merits an understanding of resources consumed by MBs during an episode of care that includes an index TAVR procedure and extends through post-discharge follow-up.

In light of this context, this study divides MBs into two study cohorts: those who received a PPM during their index TAVR hospitalization and those who did not. Resource utilization is reported for both groups using the metrics of hospital length of stay and Medicare reimbursement for three time periods: the MBs' index TAVR hospitalization, the 365-day post-discharge follow-up period, and the total episode of care. Additionally, the most common reasons for hospital readmission are reported for all MBs, which may be of use to hospitals seeking to reduce costly readmissions. Of note, during the study period approval for MB TAVR procedures was limited to the "high risk" patient cohort.

Methods

Data source

Centers for Medicare and Medicaid Service's Inpatient and Outpatient Standard Analytical Files (IPSAF and OPSAF) linked data for calendar years 2014, 2015, and 2016 are the data sources for this retrospective analysis. These files allow researchers to link all acute care and outpatient services utilized for an individual MB. The IPSAF data file contained information to calculate length of stay in days, discharge status, total Medicare reimbursement, International Classification of Disease, 9th or 10th Edition Clinical Modification (ICD-9-CM or ICD-10-CM) diagnoses and procedures codes, and diagnosis related category (DRG). While the OPSAF data file contains procedure codes to identify PPM or cardioverter-defibrillator (ICD) implantation performed in the outpatient setting during the study period, but Medicare reimbursement for outpatient episodes was not collected.

Study population

The population in this study consists of MBs in the IPSAF who underwent TAVR in a US hospital between January 1, 2014 and June 30, 2015. MBs undergoing TAVR were identified using the following ICD-9-CM procedure code: 35.05. A total of 20,682 TAVR hospitalizations were identified as meeting the inclusion criteria. A MB's TAVR hospitalization was excluded from the study population for four reasons: 1) the MB's TAVRs hospitalization's discharge date was missing (n = 7); 2) the TAVR procedure identified was not the MBs first TAVR hospitalization in the study period (n = 13); 3) the MB had a previous PPM or ICD (n = 2,844); or 4) the MB died during the index hospitalization or the follow-up period (n = 2,292). Because seven MBs were excluded for multiple reasons, the final study sample consists of 15,533 who survived for 365 days following their first TAVR procedure between January 1, 2014 and June 30, 2015. Two study cohorts were created based on whether or not the MBs received a permanent pacemaker implantation (PPM) identify by ICD-9-CM codes (37.80, 37.81. 37.82, 37.82, 37.83, 37.85, 37.86, 37.87, 00.50 or 00.53) during their index TAVR hospitalization.

Unit of analysis and analytical file

The unit of analysis is a MB. To construct the analytical file, the hospital file was searched to identify each MB's initial TAVR hospitalization, including all relevant utilization, reimbursement, and discharge destination information associated with the index TAVR. Next, the IPSAF and OPSAF hospital files for 2014, 2015, and 2016 were searched for all encounters within 365 days of the discharge date of the index TAVR hospitalization. A MB's claims were converted into a beneficiary level file by summing, averaging or counting the relevant data information obtained from all follow-up encounters. If a MB did not have any hospital readmissions or outpatient procedures all relevant study information was set equal to zero for that MB.

Statistical analysis

Univariate differences between MBs who did and did not receive a PPM during their index TAVR hospitalization were assessed using χ^2 analysis or the Fisher exact test when χ^2 analysis could not be performed due to expected counts less than five. Observed resource utilization statistics were reported as mean ± SD, median, first quartile, and third quartile values. Differences in resource utilization were tested using one-way ANOVA statistic with median score (number of points above the median). Differences between study groups were considered statistically different if the p-value was less than or equal to 0.001. Median regression models were run to estimate risk-adjusted differences in median resource usage between the two study groups after controlling for demographic characteristics and 47 comorbid conditions. All analyses were performed with SAS 9.4 (SAS Institute, Cary, North Carolina).

Demographic and comorbidity controls

All demographic and comorbid conditions were created based on information contained in the claim information associated with the index TAVR hospitalization. Demographic variables of interest included: age group (under 65, 65 to 69, 70 to 74, 75 to 79, and 80 plus), gender, and race (white, or non-white). All comorbid conditions were identified using ICD-CM-9 or ICD-CM-10 codes that were present on admission during the index hospitalization.

Results

Overall, MBs undergoing a TAVR during the study period were most likely to be older than 80 (69%), white (93%) and male (51%) (Table 1). In addition, MBs during their index TAVR reported a variety of comorbid conditions, Table 1 reports on 19 different conditions experienced by more than 10% of MBs in the study populations. A comparison of demographic conditions between the two study cohorts indicated significant differences in the age distribution (MBs receiving a PPM were more likely to be over 80 years of age (72.95% versus 68.66%) and male (54.93% vs 50.50%).

The average length of stay (LOS) for all MBs during their index TAVR hospitalization was 6.4±5.7 days while the median length of stay was 5.0 days (interquartile range for LOS was 3.0 to 7.0 days) (Table 2). Medicare reimbursed hospitals an average of $50,822 ± $19,834 for the index hospitalization and the median Medicare reimbursement was $48,530 (interquartile range for reimbursement was $39,574 to $59,307). The vast majority of MBs were discharged from their index TAVR hospitalization to one of three destinations: home (39.9%), home with a home health agency (32.5%), or skilled nursing facility (20.4%).

A comparison of the two study cohorts indicated that MBs in the PPM cohort consumed more resources than those MBs not receiving a PPM during their index TAVR hospitalization. The observed differences were 7.9 vs 6.1 days for index LOS and $55,597 vs $49,996 for Medicare reimbursement, respectively, while the median values were 6.0 vs 4.0 days LOS and $55,597 vs $49,996 for Medicare reimbursement. The one-way ANOVA test indicates that significantly more observations were above the median value for MBs in the PPM cohort for both resource measures. Finally, MBs in the PPM cohort were significantly less likely to be discharged home (29.4% vs 41.7%), and significantly more likely to be discharged to a home health agency (35.5% vs 32.0%), a skill nursing facility (25.9% vs 19.5%) or a rehabilitation facility (6.9% vs 4.8%).

Part A of table 3 provides study statistics on hospitalizations occurring during the 365-day follow-up period for all MBs in the study. Four findings are worth noting. First, 8,390

Table 1: Baseline demographic and coronary risk factors present in more than 10% of MBs undergoing a TAVR index hospitalization or for factors with significantly differences between study cohorts.

		Received Pacemaker Implantation		
	All MBs	Yes	No	*p* - value
	(n = 15,533)	(n = 2,292)	(n = 13,241)	
Age (age categories)				
<65, %	1.79	1.66	1.81	
65-69, %	5.09	3.49	5.37	
70-74, %	9.08	8.03	9.26	
75-79, %	14.75	13.87	14.90	
≥80, %	69.29	72.95	68.66	$p < 0.001$
Gender				
Male, %	51.16	54.93	50.50	$p < 0.001$
Race				
White	92.72	93.15	92.64	
Non-white	7.28	6.85	7.36	$p = 0.389$
Comorbidities				
Obesity, %	16.09	16.45	16.03	$p = 0.618$
Body mass index greater than 30, %	12.02	11.87	12.05	$p = 0.808$
Type II diabetes mellitus, %	36.36	38.48	35.99	$p = 0.022$
History of smoking, %	29.47	29.01	29.54	$p = 0.607$
Heart failure, %	75.11	76.00	74.96	$p = 0.285$
Chronic ischemic heart disease, %	71.61	72.86	71.37	$p = 0.150$
Prior myocardial infarction	12.88	12.13	13.01	$p = 0.248$
Hypertension	87.25	86.04	87.46	$p = 0.059$
Chronic obstructive pulmonary disease, %	32.34	30.37	32.68	$p = 0.029$
Moderate chronic kidney disease, %	17.70	18.59	17.54	$p = 0.227$
Chronic kidney disease, unspecified, %	10.90	10.34	11.00	$p = 0.352$
Peripheral vascular disease, %	23.65	23.25	23.71	$p = 0.633$
Hyperlipidemia, %	69.47	69.90	69.39	$p = 0.628$
Atrial fibrillation, POA, %	35.70	38.57	39.20	$p = 0.002$
Heart Block, POA, %	14.80	26.57	12.76	$p < 0.001$
RBBB Block, POA, %	3.30	7.72	2.53	$p < 0.001$
LBBB, Block, POA, %	6.31	6.46	6.28	$p = 0.752$
Other Conduction Disorder, POA, %	6.98	16.56	5.32	$p < 0.001$
Prior PCI, %	22.09	22.99	21.93	$p = 0.258$
Prior CABG, %	22.94	22.77	22.97	$p = 0.840$
Anemia, POA %	27.61	26.96	27.72	$p = 0.452$
Prior cerebral vascular accident, %	11.83	11.82	11.83	$p = 0.988$

Table 2: Observed Index Hospital Resources, Outcomes, and Discharge Status of Medicare Beneficiaries during their Index TAVR Hospitalization and by whether or not the Medicare Beneficiary Received a Pacemaker Implantation.

	All MBs	PPM Implanted during TAVR Admission	No PPM Implanted during TAVR Admission	*p* - value
Total Average Resource Utilization Statistics associated with index TAVR hospitalization:				
Length of Stay Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 6.4 ± 5.7 5.0 3.0 7.0	 7.9 ± 6.1 6.0 4.0 9.0	 6.1 ± 5.6 4.0 3.0 7.0	*p* < 0.001*
Medicare Reimbursement Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 $50,823 ± $19,834 $48,530 $39,574 $59,307	 $55,597 ± $19,781 $52,843 $43,407 $64,396	 $49,996 ± $19,727 $47,504 $38,987 $58,169	*p* < 0.001*
Outcomes:				
Other Valve Procedures during Index TAVR:				
Valvuloplasty, %	0.05	0.00	0.06	*p* = 0.614**
Valve with Tissue, %	0.20	0.39	0.17	*p* = 0.038**
Valve with Other, %	0.07	0.00	0.08	*p* = 0.386**
Hospital Discharge Destination:				
Home, %	39.9	29.4	41.7	*p* < 0.001
Home Health Agency, %	32.5	35.5	32.0	*p* = 0.001
Skilled Nursing Care, %	20.4	25.9	19.5	*p* < 0.001
Rehabilitation Facility, %	5.1	6.9	4.8	*p* < 0.001
Other Discharge Status, %	2.0	2.4	2.0	*p* = 0.180

**p* - value reports the one-way ANOVA statistic for median score (points above the median). All other *p* - values were calculated using the Chi-Squared test.
**More than 20% of cells had expected counts less than 5; *p* - value instead reports a two-sided Fisher's exact test.

Table 3: Observed Hospital Resource Utilization Statistics of Medicare Beneficiaries during the 365-days following their Index TAVR Hospitalization and by whether or not the Medicare Beneficiary received a pacemaker implantation during their index TARV admission.

	All MBs	PPM Implanted during TAVR Admission	No PPM Implanted during TAVR Admission	*p* - value
Part A: Statistics for 365-day Follow-up for all MBs:				
Number of Hospital Readmissions (MBs, %):				
0	8,390 (54.0)	1,258 (54.9)	7,132 (53.9)	*p* = 0.252
1	3,572 (23.0)	499 (21.8)	3,073 (23.2)	
2	1,738 (11.2)	264 (11.5)	1,474 (11.1)	
3	899 (5.8)	146 (6.4)	753 (5.7)	
4 or more	934 (6.0)	125 (5.5)	809 (6.1)	
Range of Hospital Visits	0 – 15	0 – 10	0 – 15	-NA-
Total LOS Mean ± Std. Median Value 3rd Quartile Value	 4.83 ± 9.38 0 6	 4.91 ± 9.63 0 6	 4.82 ± 9.34 0 6	*p* = 0.213*
Medicare Reimbursement Mean ± Std. Median Value 3rd Quartile Value	 $9,815 ± $18,898 $0.00 $12,647	 $9,876 ± $19,239 $0.00 $13,074	 $9,804 ± $18,839 $0.00 $12,592	*p* = 0.129*
Part B: Statistics during 365-day Follow-up for MBs with at Least One Hospital Readmission:				
Number of MBs	7,143	1,034	6,109	-NA-
First Hospitalization during 365-day Follow-up Period:				
Average Days to First Readmission Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 111.1 ± 105.6 75 19 185	 112.6 ± 106.3 74 20 187	 110.9 ± 105.4 75 18 185	*p* = 0.445*
Average LOS Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 4.85 ± 4.70 4.0 2.0 6.0	 5.23 ± 5.59 4.0 2.0 6.0	 4.78 ± 4.53 4.0 2.0 6.0	*p* = 0.136*
Distribution of Days to First Readmission (% (count of MBs)):				
Same Day Readmission	0.5% (38)	1.3% (13)	0.4% (25)	*p* < 0.001
1 to 30 Days	31.8% (2,273)	30.1% (311)	32.1% (1,962)	*p* = 0.193
31 Days to 90 Days	22.3% (1,589)	23.8% (246)	22.0% (1,343)	*p* = 0.196
91 Days to 180 Days	19.5% (1,392)	18.7% (193)	19.6% (1,199)	*p* = 0.471

181 Days to 360 Days	25.9% (1,851)	26.2% (271)	25.9% (1,580)	$p = 0.815$
Part C: All Hospitals during 365 day Follow-up Period:				
Total LOS Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 10.5 ± 11.5 7.0 3.0 13.0	 10.9 ± 11.9 7.0 3.0 14.0	 10.4 ± 11.4 7.0 3.0 13.0	$p = 0.082$*
Medicare Reimbursement Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 $21,343 ± $23,034 $14,113 $7,451 $26,587	 $21,891 ± $23,615 $14,662 $7,548 $27,236	 $21,250 ± $22,935 $13,966 $7,451 $26,538	$p = 0.089$*
Valve Procedures during 365-day follow-up period:				
Any Valve, % (Count)	1.50 (107)	1.74 (18)	1.46 (89)	$p = 0.487$
Any TAVR, % (Count)	1.06 (76)	1.26 (13)	1.03 (63)	$p = 0.513$
Any SAVR, % (Count)	0.34 (24)	0.39 (4)	0.33 (20)	$p = 0.760$
Any PPM or ICD Procedures (Inpatient or Outpatient) during 365-day follow-up period:				
PPM, % (Count)	3.94 (612)	1.27 (29)	4.40 (583)	$p < 0.001$
ICD, % (Count)	0.82 (128)	0.52 (12)	0.88 (116)	$p = 0.102$
Most Frequent Reason for Hospital Readmission in Selected DRG Category:				
Pulmonary Edema & Respiratory Failure, % (Count)	23.1 (1,648)	28.1 (291)	22.2 (1,357)	$p < 0.001$
Heart Failure, % (Count)	21.5 (1,534)	27.2 (281)	20.5 (1,253)	$p < 0.001$
Sepsis, % (Count)	11.2 (799)	10.2 (105)	11.4 (694)	$p = 0.255$
COPD/Pneumonia, % (Count)	10.5 (749)	9.5 (98)	10.7 (651)	$p = 0.253$
GI Bleed with Hemorrhage, % (Count)	8.6 (617)	8.6 (89)	8.6 (528)	$p = 0.970$
Renal Failure, % (Count)	5.9 (418)	5.6 (58)	5.9 (360)	$p = 0.719$
Arrhythmia, % (Count)	6.1 (433)	4.6 (48)	6.3 (385)	$p = 0.039$
Urinary Track, % (Count)	5.4 (387)	6.5 (67)	5.2 (320)	$p = 0.103$

*p - value reports the one-way ANOVA statistic for median score (points above the median). All other p-values were calculated using the Chi-Squared test.

(54.0%) of the MBs surviving the study period did not have any hospitalizations during the follow-up period. 3,572 MBs (23.0%) experienced only one hospitalization during the follow-up period. However, 11.8% of MBs had three or more hospitalizations during the follow-up period (maximum was 15 hospitalizations). Second, amongst all MBs, the average total hospital LOS during the follow-up period was 4.83 ± 9.38 days. Third, average total hospital reimbursement for all MBs during the follow-up period was $9,815 ± $18,898. Note the median LOS and Medicare reimbursement were both 0 as 54% of the MBs did not have a readmission. Finally, the one-way ANOVA test indicates no significantly differences in the number of observations above the median value for either resource measure between the two-study cohorts.

Part B of table 3 reports study resource statistics among the 7,143 MBs first hospitalization during the follow-up period. Approximately 32% of MBs had their first readmission within 30 days of their index TAVR. On the other hand, approximately 26% of the MBs first hospital readmission did not occur until at least 181 days after their TAVR discharge. On average, the first hospital readmission occurred 111.1±105.6 days after discharge from their index TAVR, while the median numbers to the first readmission was 75 days (interquartile range 19 to 185 days). Part C of table 3 reports resource utilization on all hospitalizations during the 365-day follow-up period among MBs that experienced at least one hospitalization. The average total LOS during the entire follow-up period among MBs with a hospitalization was 10.5 ± 11.5 (median 7 days, interquartile range 3 to 13 days) and average total Medicare reimbursement was $21,343 ± $23,034 (median $14,113, interquartile range $7,451 to $26,587). The one-way AVOVA test found no significant differences in the distribution of any of these resource measures during the follow-up period between the two study cohorts in table 3. It is interesting to note that during the follow-up period, 107 MBs (1.5%) had an additional valve procedure, of which 76 had a second TAVR procedure. Further, the four most common reasons (based on DRG categories) for hospital readmissions during the follow-up period were: pulmonary edema and respiratory failure (23.1%), heart failure (21.5%), sepsis (11.2%) and COPD or pneumonia (10.5%). MBs in the PPM cohort were significantly more likely to have a readmission associated with pulmonary edema and respiratory failure (28.1% vs 22.2%) and heart failure (27.2% vs 20.5%).

Table 4 reports total hospital resource utilization by combining the index TAVR hospitalization with the 365-day follow-up period. Part A indicates that average total hospital LOS was 11.2 ± 11.7 days and median LOS was 7.0 days (interquartile range 4.0 to 14.0 days) during the entire episode. Average total Medicare reimbursement was $60,638 ± $28,974 and median Medicare reimbursement was $54,849 (interquartile range $43,236 to $71,007). Overall, the index TAVR hospitalization accounted for approximately 84% of all Medicare reimbursement during the study period. The one-way ANOVA test indicates that significantly more observations in the distributions for LOS and Medicare reimbursement were above the median value for MBs in the PPM cohort.

Table 4: Observed and Risk-Adjusted Hospital Resource Utilization during the Entire Study Period for all Medicare Beneficiaries and by whether or not the Medicare Beneficiary received a pacemaker implantation during their index TARV admission.

	All MBs	PPM Implanted during TAVR Admission	No PPM Implanted during TAVR Admission	*p* - value*
Number of MBs	15,533	2,292	13,241	-NA-
Part A: Observed Resource Utilization Statistics during Study Period:				
Length of Stay Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 11.2 ± 11.7 7.0 4.0 14.0	 12.8 ± 12.1 9.0 5.0 16.0	 10.9 ± 11.6 7.0 4.0 14.0	 *p* < 0.001
Reimbursement Mean ± Std. Median Value 1st Quartile Value 3rd Quartile Value	 $60,638 ± $28,974 $54,849 $43,236 $71,007	 $65,473 ± $29,053 $59,756 $47,342.50 $77,196.50	 $59,801 ± $28,879 $54,019 $42,610 $69,712	 *p* < 0.001
Part B: Risk-Adjusted Median Regression Estimates of Resource Utilization during Study Period:				
	Estimated Impact of Receiving PPM During Index Admission***		*p* - value**	
Length of Stay (days) (95% Confidence Interval)	1.84 (1.48 to 2.20)		*p* < 0.001	
Medicare Reimbursement (95% Confidence Interval)	$5,132 ($3,995 to $6,270)		*p* < 0.001	

**p* - values in Part A report the one-way ANOVA statistic for median score (points above the median).
***p* - values in Part B report the result of the Median Regression for the indicator variable that a Medicare Beneficiary received a PPM during their index TAVR admission.
***Regression model controlled for all variables listed in table 1 and the following comorbid conditions: Body mass index less than 19, Type I diabetes mellitus, Current smoker, Acute renal failure, Unstable angina, Malnutrition, Dementia, Depression, Acute respiratory failure, chronic respiratory failure, Mild chronic kidney disease, Severe chronic kidnsey disease, Dialysis dependent, Chronic liver disease, Aortic Aneurysm, Cardiomyopathy, Cardiogenic shock, Cardiac arrest , Primary STEMI, Primary Non-STEMI, Prior value surgery, Prior venous thromboembolism, cancer, or AIDS.

Part B of table 4 reports estimated incremental resource utilization between the two study cohorts obtained from the risk-adjusted median regression models for total episode hospital LOS and Medicare reimbursement. The results of the median regression models indicate that median Medicare reimbursement was significantly higher ($5,132) and median LOS was significant longer (1.84) days in the PPM cohort after controlling for difference in demographic characteristics and observed comorbid conditions between the two study cohorts.

Discussion

This analysis reports a set of nationally representative Medicare benchmarks for a MB's index TAVR hospitalization and all hospital encounters during a 365-day follow-up period. First, total average Medicare reimbursement to hospitals among the 15,533 MBs undergoing a TAVR procedure was $60,638 ± $28,974 for the entire study period. Average Medicare reimbursement for the index TAVR hospitalization accounted for 83.8% of total average reimbursement for the entire study period. Second, 54.0% (8,390) of the MBs undergoing a TAVR procedure did not have any hospital readmissions during the 365-day follow-up period. Third, MBs in the PPM cohort had higher average Medicare reimbursement during both the index TAVR hospitalization ($55,597 ± $19,781 versus $49,996 ± 19,727) and for the entire study period ($65,473 ± $29,053 versus $59,801 ± $28,879) than MBs in the non-PPM cohort. Finally, this study provides insight into the clinical reasons associated with MBs having a hospitalization following TAVR. The two most common DRG categories for readmission were pulmonary edema/respiratory failure and heart failure.

This paper provides insights into the financial risks that healthcare providers will incur if a provider proceeds with a bundle payment program for TAVR procedures. After controlling for demographics and 47 comorbid conditions, this paper finds statistically significant longer total lengths of stay (1,8 days) and higher Medicare reimbursements ($5,132) for MBs receiving PPM implantations. This paper finds that nearly 55% of MBs first hospital readmission occurred within 90 days of the index TAVR hospitalization. Further, average Medicare reimbursement during follow-up hospitalization for all MBs with at least one readmission in this study was $21,343 ± $23,034, approximately 42% of observed average Medicare reimbursement during the index TAVR hospitalization.

Furthermore, this paper provides insight into the clinical problems that resulted in readmissions during the follow-up period. In particular, this paper findings that over 4.0% of TAVR patients not receiving PPM during their index hospitalization underwent PPM procedures during the follow-up period. This finding supports concerns related to atrioventricular block following TAVR [18] and gives providers insight into potential bundling of devices from manufacturers to cover this additional cost. In addition, under bundled payments, it will be financially advantageous to manage the comorbid conditions associated with readmissions. Given that 44.6% of readmissions were due to pulmonary edema and respiratory failure or heart failure, there appears to be opportunity for outpatient intervention, remote monitoring, telemedicine follow-up or other preemptive maneuvers to help avoid these readmissions. Finally, this study found MBs in the PPM cohort were significantly more likely to use post-acute care, including home health agencies (35.5% vs 32.0%), skilled nursing

facilities (25.9% vs 19.5%) and rehabilitation hospitals (6.9% vs 4.8%) and less likely to be discharged home (29.4% vs 41.7%).

Several limitations warrant discussion. First, this analysis applies only to MBs in the fee-for service program. A second limitation is that this study does not have any information concerning the resources consumed for using post-acute care services or outpatient procedures during the follow-up period. Another limitation of this study is Medicare reimbursement in this study is observed based on the payment rule and financial incentives in the Medicare program during 2014 to 2016. It is not possible to speculate how hospitals and other healthcare providers will change their patterns of care, in response to the new financial incentives associated with future Medicare's bundle payment programs and other value-based delivery models.

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