Article published online: 2021-08-09

ORIGINAL ARTICLE

Impact of hospital and sociodemographic factors on utilization of drug-eluting stents in 2011–2012 Medicare cohort

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Access this article online

Website: www.avicennajmed.com

DOI: 10.4103/2231-0770.197509

Quick Response Code:

ABSTRACT

Objective: Insurance status is a predictor of drug-eluting stent (DES) usage. Our study sought to determine the effect of hospital and sociodemographic characteristics on utilization of DES in nationwide inpatient discharges with uniform insurance (Medicare). **Methods:** We linked data from the 2011 to 2012 Medicare discharges, 2011 Medicare hospital referral region (HRR) report (racial composition of each HRR), American Hospital Association (number of beds, rural/urban location, public/private status, and academic affiliation of hospitals), and American Community Survey 2011 (median income using zip code). We analyzed diagnosis-related group (DRG) codes 249 (bare metal stent without complications), 246, and 247 (DES with and without complications, respectively). Univariate and multivariable logistic regression was conducted to determine odds ratios (OR) for utilization of DES. **Results:** There were 322,002 discharges with DRG codes 246 (54,279), 247 (209,365), and 249 (58,358) in our database. Higher odds of DES usage was observed in Hispanic dominant HRR(s) (OR: 1.37, 95% confidence interval [CI]: 1.33–1.42, $P < 0.001$) compared to Caucasian dominant HRR(s). DES utilization was similar in African-American and Caucasian dominant HRR (s). Higher odds of DES use was observed in median household income groups ≥$20,001 (OR: 1.07, 95% CI: 1.01–1.13, P - 0.03). Lower DES usage was observed in hospitals with higher total stent volume (quartile 4 vs. quartile 1: OR: 0.66, 95% CI: 0.63–0.69, $P < 0.001$) and for-profit hospitals (OR: 0.88, 95% CI: 0.85–0.92, $P < 0.001$). **Conclusions:** Our study findings suggest that there are significant differences in DES utilization in a national cohort of individuals with uniform insurance.

Key words: Drug-eluting stent utilization, Medicare, sociodemographic factors

INTRODUCTION

Drug-eluting stents (DES) have been in use in the United States for over a decade. In 2003, the first coronary DES received approval by the Food and Drug Administration, after clinical trials demonstrated their superiority over bare metal stents (BMSs) for the treatment of native coronary artery stenosis due to lower rates of angiographic restenosis and target vessel revascularization.[1-4] Presently, more than 80% of coronary stents used in the United States are DES.[5]

Studies have revealed disparities in DES utilization based on patient, hospital, and sociodemographic characteristics.[5-8] Hospital characteristics such as bed size, location, academic affiliation, procedural volume, and sociodemographic characteristics including race, income, and insurance

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Cite this article as: Tuliani TA, Shenoy M, Parikh M, Cohen MG, Grines C, Jutzy K, *et al*. Impact of hospital and sociodemographic factors on utilization of drug-eluting stents in 2011-2012 Medicare cohort. Avicenna J Med 2017;7:17-22.

have been associated with disparities in DES utilization. Hospitals with a smaller number of beds, West geographic region, African-American race, Hispanic ethnicity, and low income ($20,000–30,000) are factors associated with the lower use of DES.[5-11] Status and type of insurance have consistently been a major predictor as well.[5,7,10,12] Medicaid and lack of insurance have been associated with lower use of DES.[7,8,12] On the other hand, patients with private insurance are more likely to be treated with DES.[5,10] We sought to assess the influence of hospital and sociodemographic characteristics on stent choice in a population covered by Medicare, to eliminate the effect of insurance status in a real-world inpatient setting.

METHODS

Recently, Centers for Medicare and Medicaid Services (CMS) released information regarding more than 3000 U.S. hospitals that receive Medicare Inpatient Prospective Payment System payments for the top 100 frequently billed discharges, based on a rate per discharge using the Medicare severity diagnosis-related group (MS-DRG) for Fiscal Year (FY) 2011 and 2012 (October 1, 2010 to September 30, 2012). Of the top 100 MS-DRGs in this cohort, we abstracted data regarding MS-DRG codes: 246 (percutaneous cardiovascular procedure with DES with major complication or comorbidity [MCC] or 4+ vessels/stents), 247 (percutaneous cardiovascular procedure with DES without MCC), and 249 (percutaneous cardiovascular procedure with non-DES without MCC). Data on MS-DRG 248 (percutaneous cardiovascular procedure with non-DES with MCC) were not released as it was not one of the 100 frequently billed MS-DRGs.

We queried discharges in FY 2011 and 2012 for Medicare beneficiaries, who underwent PCI in the inpatient setting. Data points of interest included DRG code, provider information identification number, name, address, hospital referral region (HRR) description, and total discharges. There were 168,023 and 153,979 discharges from 1436 to 1478 hospitals for FY 2011 and 2012, respectively.

Our data lacked individual patient demographics. Therefore, a racial composition for each HRR (total of 306 HRRs) was ascertained from 2011 Medicare HRR Report (http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Geographic-Variation/GV_PUF.html). HRRs were classified as African-American, Hispanic, and combined African-American and Hispanic dominant areas if the prevalence of that particular race was >90th percentile cutoff for the Medicare population. The 90th percentile cutoff for African-American and Hispanic prevalence in HRRs was 23.1% and 12.2%, respectively. HRRs with African-American and Hispanic prevalence <90th percentile were classified as non-Hispanic Caucasian dominant. Using provider zip code from CMS data, data regarding family median income (5-year inflation-adjusted estimates) were obtained from the American Community Survey 2011. Family median annual income was categorized in ≤$20,000 and >$20,001.

We extracted data about total hospital bed size, ownership status, academic affiliation, location (urban/rural; state; geographic region [Northeast, Midwest, South, and West]) from the American Hospital Association database. Hospitals were divided into quartiles based on bed size (FY 2011: quartile 1 ≤190, quartile 2 191–289, quartile 3 290–428, and quartile 4 ≥429; FY 2012: Quartile 1 ≤185, quartile 2 186–284, quartile 3 285–425, and quartile 4 >425) and total institutional stent discharges (FY 2011: Quartile 1 ≤41, quartile 2 42–84, quartile 3 85–145, and quartile 4 ≥145; FY 2012: Quartile 1 ≤38, quartile 2 39–75, quartile 3 76–131, and quartile 4 >131).

Categorical variables were presented as frequencies with their respective percentages and were compared with Chi-square test. $P < 0.05$ was considered statistically significant. Multivariable logistic regression was conducted to identify individual predictors associated with DES utilization. Covariates included in multivariable regression were: Racial composition of HRR, median household income, total institutional stent volume, hospital bed size, hospital academic affiliation, urban/rural location, hospital ownership status, and geographic census region. Covariates in the models were displayed as odds ratio (OR) with 95% confidence interval (CI). We also repeated the same analytical steps for DES and BMS discharges, limited to MS-DRGs without MCC (MS-DRG 247 vs. MS-DRG 249). All statistical analyses were performed with STATA 11 (StataCorp., College Station, Texas, USA).

RESULTS

A total of 322,002 admitted patients in FY 2011 and 2012 received coronary stents with MS-DRG codes 246 (54,279 discharges), 247 (209,365 discharges), and 249 (58,358 discharges). DES was used in 263,644 (81.88%) discharges and BMS in 58,358 (18.12%) discharges. There were 267,723 discharges with stent placement (DES/BMS) without MCC; 78.2% received DES and 21.8% received BMS. Comparison of hospital and sociodemographic characteristics between DES and BMS discharges is listed in Table 1.

Table 1: Baseline characteristics by type of stent

	Bare metal stent without MCC MS-DRG 249 58,358 (18.1%)	Drug-eluting stent with MCC MS-DRG 246 54,279 (16.9%)	Drug-eluting stent without MCC MS-DRG 247 209,365 (65%)	*P*$
Racial composition*				
Caucasian dominant	47,466 (18.7)	41,404 (16.3)	164,968 (65)	<0.001
African-American dominant	5800 (18.8)	5634 (18.2)	19,449 (63)	
Hispanic dominant	4700 (13.7)	6629 (19.3)	22,966 (67)	
African-American and Hispanic dominant	392 (13.1)	612 (20.5)	1982 (66.4)	
Median household income				
≤$20,000	1438 (19.1)	1368 (18.1)	4713 (62.7)	<0.001
≥$20,001	56,920 (18.1)	52,911 (16.8)	204,652 (65.1)	
PCI volume (quartiles)				
1: (2011: ≤41; 2012: ≤38)	2054 (12)	793 (4.7)	14,194 (83.3)	<0.001
2: (2011: 42–84; 2012: 39-75)	7899 (18.4)	6839 (16)	28,120 (65.6)	
3: (2011: 85–145; 2012: 76-131)	14,717 (19.2)	13,691 (17.9)	48,125 (62.9)	
4: (2011: >145; 2012: >131)	33,688 (18.1)	32,956 (17.8)	118,926 (64.1)	
Hospital ownership				
Government nonfederal	4648 (17.6)	4802 (18.2)	16,946 (64.2)	<0.001
Nongovernment not for-profit	43,972 (18)	41,311 (16.9)	159,260 (65.1)	
Investor owned for-profit	9738 (19.1)	8166 (16)	33,159 (64.9)	
Geographic region				
Northeast	11,403 (20.2)	8609 (15.2)	36,564 (64.6)	<0.001
Midwest	16,279 (18.6)	13,684 (15.6)	57,722 (65.8)	
South	25,027 (18.5)	23,856 (17.7)	86,217 (63.8)	
West	5649 (13.2)	8130 (19.1)	28,862 (67.7)	
Academic affiliation				
Yes	37,447 (18.3)	35,615 (17.4)	131,513 (64.3)	<0.001
No	20,911 (17.8)	18,664 (15.9)	77,852 (66.3)	
Location				
Urban	53,574 (18)	50,534 (17)	192,770 (65)	<0.001
Rural	4784 (19)	3745 (14.9)	16,595 (66.1)	
Hospital bed size (quartiles)				
1: (2011: ≤190; 2012: ≤185)	7755 (17.5)	6035 (13.6)	30,525 (68.9)	<0.001
2: (2011: 191-289; 2012: 186-284)	11,140 (18.9)	9461 (16.1)	38,319 (65)	
3: (2011: 290-428; 2012: 285-425)	14,724 (17)	14,979 (17.2)	57,102 (65.8)	
4: (2011: ≥429; 2012: >425)	24,739 (18.8)	23,804 (18)	83,419 (63.2)	

*HRR with ≥23.1% (90th percentile) African-Americans and <12.21% Hispanics were grouped as African-American dominant HRRs. HRRs with ≥12.21% (90th percentile) Hispanics and <23.1% African-Americans were grouped as Hispanic dominant HRRs. HRRs with <23.1% African-Americans and<12.21% Hispanics were grouped as Caucasian dominant HRRs, $P value for Chi-squared test between MS-DRG 246, 247 and 249 use across individual determinants in column 1. HRRs: Hospital referral regions, MCC: Major complication or co-morbidity, MS-DRG: Medicare severity diagnosis related group, PCI: Percutaneous coronary intervention

Impact of sociodemographic characteristics on stent discharges

Patients in the higher income group (>$20,001) were more likely to receive a DES (OR: 1.07, CI: 1.01–1.13, *P* - 0.03) [Table 2]. There was no significant difference in DES utilization between African-American and Caucasian dominant HRRs. A higher proportion of DES use was observed in Hispanic dominant HRRs (OR: 1.37, CI: 1.33–1.42, *P* < 0.001).

Impact of hospital characteristics on stent discharges

Institutional annual stent discharges ranged from 11 to 1470 from a single hospital (FY 2011: Median 84; FY 2012: Median 75). DES use was lower in higher volume hospitals: quartile 2 (OR: 0.6, 95% CI: 0.57–0.63, *P* < 0.001), quartile 3 (OR: 0.58, 95% CI: 0.55–0.61, *P* < 0.001), and quartile 4 (OR: 0.66, 95% CI: 0.63–0.69, *P* < 0.001) compared to quartile 1. Lower DES use was observed in investor-owned for-profit hospitals (OR: 0.88, 95% CI: 0.85–0.92, *P* < 0.001). There was a higher DES use in the Midwest (OR: 1.17, 95% CI: 1.14–1.20, *P* < 0.001), South (OR: 1.19, 95% CI: 1.16–1.23, *P* < 0.001), and West (OR: 1.65, 95% CI: 1.59–1.71, *P* < 0.001) geographic region as compared to the Northeast geographic region. There were 758 (52.8%) and 767 (51.9%) hospitals with academic affiliation for FY 2011 and FY 2012, respectively. Hospitals with academic affiliation accounted for 63.5% discharges in our dataset. Patients admitted to hospitals with academic affiliation were as likely to receive a DES as those admitted to nonteaching hospitals (OR: 0.98, 95% CI: 0.95–1.01, *P* - 0.2). Most hospitals in our database were located in urban areas (FY 2011: 1292 [90%]; FY 2012: 1324 [89.6%]). There was no difference in stent use between urban and rural hospitals (OR: 1.03, 95% CI: 0.99–1.07, *P* - 0.07).

Hospital size according to a number of beds ranged from 12 to 2338 beds (FY 2011: Median 288; FY 2012:

Table 2: Factors influencing drug-eluting stent utilization: Multivariable logistic regression model

Determinant	OR for DES utilization	*P*
Racial composition (referent: Caucasian dominant HRR)		
African-American dominant HRR	1.01 (0.97-1.04)	0.7
Hispanic dominant HRR	1.38 (1.33-1.42)	<0.001
African-American and Hispanic dominant HRR	1.64 (1.47-1.82)	<0.001
Median household income (referent ≤$20,000)		
>$20,000	1.07 (1.01-1.13)	0.03
PCI volume (referent: Quartile 1)		
Quartile 2	0.60 (0.57-0.63)	<0.001
Quartile 3	0.58 (0.55-0.61)	<0.001
Quartile 4	0.66 (0.63-0.7)	<0.001
Hospital ownership (referent: Government nonfederal)		
Nongovernment not for-profit	1.01 (0.98-1.05)	0.5
Investor owned for profit	0.88 (0.85-0.92)	<0.001
Geographic region (referent: Northeast)		
Midwest	1.17 (1.14-1.20)	<0.001
South	1.19 (1.16-1.23)	<0.001
West	1.65 (1.59-1.7)	<0.001
Academic affiliation	1.02 (0.99-1.04)	0.2
Urban location	1.02 (0.99-1.07)	0.2
Hospital bed size (referent: Quartile 1)		
Quartile 2	0.94 (0.91-0.97)	<0.001
Quartile 3	1.07 (1.03-1.1)	<0.001
Quartile 4	0.93 (0.89-0.96)	<0.001

OR: Odds ratio, PCI: Percutaneous coronary intervention, DES: Drug-eluting stent, HRR: Hospital referral region

Median 284). However, the highest proportion of DES use was observed in moderate to large-sized hospitals in quartile 3 (83% vs. 17%) (OR: 1.06, 95% CI: 1.02–1.09, *P* - 0.002). All analyses were repeated with MS-DRG 247 and 249 revealing similar results.

DISCUSSION

Our study describes the influence of hospital and sociodemographic factors on DES use in a large, nationwide sample with universal insurance coverage (Medicare). Our study showed higher DES use in Hispanic predominant areas, higher income patients (>$20,001), West geographic region, and lower DES use in for-profit hospitals. Another finding of particular interest was the lack of difference in DES use between Caucasian and African-American predominant areas.

Previous studies have shown that uninsured and Medicaid patients were less likely to receive DES[7,8,12] and private insurance predicts higher DES utilization.[5,10] In a more recent study, Gaglia *et al*. showed that patients with Medicare coverage were less likely to receive DES (OR: 0.71, 95% CI: 0.52–0.95, *P* - 0.02). Ting *et al*. reported in ST-elevation myocardial infarction patients from the National Cardiovascular Data Registry (NCDR) that among sociodemographic factors, insurance type had the greatest influence on DES use.[5] In our study, we contribute to this growing body of literature by eliminating the potential effects of heterogeneity in health insurance coverage.

Prior studies have shown racial disparities in DES usage. The finding that African-American patients are less likely to receive DES than Caucasians has been observed in prior studies.[6-8,13] However, our study shows that when insurance is uniform, DES utilization is similar in African-American and Caucasian predominant areas. This could be due to similar utilization of DES in Caucasian and African-American HRRs despite variation in prevalence of comorbid conditions and socioeconomic milieu or an underutilization of DES in African-American dominant HRRs compared to Caucasian HRRs. The higher proportion of complex DES discharges coded by MS-DRG 246 in African-American dominant HRRs compared to Caucasian dominant HRRs signifies higher prevalence of complex coronary anatomy, multivessel interventions, and higher comorbid conditions (18.2% vs. 16.3%, $P < 0.001$) [Table 1]. Whether a similar trend existed in MS-DRG code 248 (percutaneous cardiovascular procedure with non-DES with MCC) could not be verified due to unavailability of data. A Higher proportion of discharges with DES was observed from Hispanic dominant HRRs which was consistent with other studies.[5,13] Higher DES use in Hispanic could be as a result of higher prevalence of diabetes and metabolic syndrome,[14] which is a harbinger of complex coronary lesion anatomy and small caliber vessels.[15] In addition, the proportion of complex DES discharges (MS-DRG 246) was higher in Hispanic dominant HRRs compared to Caucasian HRRs (19.3% vs. 16.3%, $P < 0.001$).

Income has been reported to be a determinant of DES choice during PCI. Patients receiving DES had significantly higher median income by zip code in an analysis of 2763 patients undergoing PCI.[7] In the New York State's Percutaneous Coronary Intervention Reporting System, low-income groups received DES less frequently.[8] Despite a uniform insurance, higher odds of DES discharges in higher income groups was demonstrated in our study [Table 2]. We hypothesize implicit physician level bias toward utilization of DES in higher income groups could be a result of higher education levels in affluent groups and a belief of better medication adherence to long-term dual antiplatelet therapies.

Our study demonstrates a decreased overall proportion of DES discharges (quartile 2–4 vs. quartile 1)

[Tables 1 and 2] and a higher proportion of complex DES discharges (MS-DRG 246) from institutes with higher total stent discharges. Similarly, there was a higher proportion of complex DES discharges (MS-DRG 246) when hospitals were stratified based on bed size (quartile 1–4: 13.6%, 16.1%, 17.2%, and 18%, $P < 0.001$) [Table 1] and a lower proportion of MS-DRG 247 discharges (quartile 1–4: 68.9%, 65%, 65.8%, and 63.2%, $P < 0.001$) in larger bed size hospitals. After adjusting for covariates in multivariable regression, there was a lower odds of DES use in hospitals with higher total institutional discharges. The pattern in hospitals stratified by bed size was not consistent as seen in Table 2 with higher odds of DES use was observed in quartile 3 and lower odds for DES use was observed in quartile 2 and 4 [Table 2]. A higher proportion of complex DES discharges indicate a higher burden of complex cases in "high-volume/large bed size" institutes. We hypothesize based on our findings that "high volume" hospitals reserve DES for patients at high risk of restenosis to minimize the burden of higher costs of DES, especially with narrow "spread" of Medicare reimbursements between DES and BMS MS-DRG codes. Utilization of DES in populations with low risk of restenosis is not cost-effective for a large volume center.[16]

Lower DES usage was seen in for-profit hospitals. Epstein *et al*. demonstrated a lower likelihood of DES use in Medicare, Medicaid, and uninsured patients which was attributed to within-hospital differential treatment based on patient insurance Payer type in 4.1 million admissions from National Inpatient Sample. In our study, academic affiliation of hospitals and hospital location (urban/rural) was not significant determinants of DES use which was consistent with findings from the NCDR.[12] West geographic region was associated with increased DES use, mirroring results from the study by Ting *et al*.[5] This finding parallels the increased DES use in Hispanic dominant HRRs which were more prevalent in the West geographic regions.

Medicare physician reimbursements for coronary interventions do not vary based on the type of stent. Patient face sheet is generally included in health records and reveals information regarding insurance Payer type. It is not uncommon for physicians to examine this document during their assessment. Cultural stereotypes may not be consciously endorsed, but their mere existence influences how information is processed and leads to unintended biases in clinical decision-making, leading to implicit physician bias.[17] Regional variations in adherence to dual antiplatelet therapy could result in the development of physician preference toward higher or lower use of DES in certain high-/low-risk groups. Moreover, operator variation has been reported as a major determinant, with significant between-operator variability.[18] Introduction of newer generation DES including bioabsorbable stent scaffolds and evolution of DAPT guidelines might further influence the utilization of DES in the near future.

We examined patients in the acute inpatient setting; trends in outpatient stent utilization are beyond the scope of this paper. Our study was based on administrative claims data and thus is limited by the clinical detail such as records inherently lack including coronary anatomy, noninvasive testing, individual clinical scenarios, individual risk of stent thrombosis/restenosis, and bleeding. We did not have access to clinical information such as individual patient characteristics. Moreover, patients' personal preference could play a role in stent choice, which we were unable to ascertain from the dataset. Variables such as median income and racial composition were community characteristics, not necessarily representing the individual patient's income/race. In addition, the Medicare claims we used for this study were solely derived from fee-for-service patients older than 65 years; thus our results may not apply to younger patients or to patients covered by other types of insurance. We also did not have information on patients with secondary insurance coverage in addition to Medicare. Institutional preference for type of stent may also be affected by the rates that private insurance pays for DES at that hospital. Our study could not account for adherence to Appropriate Use Criteria of different hospitals which could potentially confound our findings. Finally, federal institutions were not included in this dataset.

Notwithstanding the limitations mentioned above including the lack of patient-level data, our study utilizes data from reliable sources to examine the effects of hospital and community level characteristics on stent utilization on a nationwide, inpatient, like insurance cohort. We observe interesting trends in DES use with lower odds of overall DES utilization in high volume centers, for-profit hospitals, and lower income groups and a higher proportion of complex DES discharges (MS-DRG 246) in "at risk" groups, i.e., low-income zip codes, African and Hispanic predominant HRRs. Whether this indicates underutilization of DES or selective utilization in high-risk cohorts cannot be delineated due to inherent limitations of our database, and the findings warrant further investigation using nationally available datasets. We postulate improved patient access to health-care facilities and providers, increased health-care dollar allocation to deprived areas, and enhanced patient education regarding disease processes could help reduce health-care disparities based on patients' income, race, and insurance status.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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