Published in final edited form as:

Med Care. 2012 January ; 50(1): 1–9. doi:10.1097/MLR.0b013e31822d5de9.

VARIATIONS IN THE USE OF AN INNOVATIVE TECHNOLOGY BY PAYER: THE CASE OF DRUG-ELUTING STENTS

Andrew J. Epstein, PhD^{*,1,2,3}, Jonathan D. Ketcham, PhD⁴, Saif S. Rathore, MPH⁵, and Peter W. Groeneveld, MD^{1,2,3}

¹Department of Veterans Affairs' Center for Health Equity Research and Promotion, Philadelphia Veterans Affairs Medical Center, Philadelphia, PA

²Division of General Internal Medicine, Department of Medicine, University of Pennsylvania School of Medicine, Philadelphia, PA

³Leonard Davis Institute for Health Economics, University of Pennsylvania, Philadelphia, PA

⁴Department of Marketing, W.P. Carey School of Business, Arizona State University, Tempe, AZ

⁵MD/PhD Program, Yale University School of Medicine, New Haven, CT

Abstract

Background—Despite receiving identical reimbursement for treating heart disease patients with bare metal stents (BMS) or drug-eluting stents (DES), cardiologists' use of the new technology (DES) may have varied by patient payer type as DES diffused. Payer-related factors that differ between hospitals and/or differential treatment inside hospitals might explain any overall differences by payer type.

Objectives—To assess the association between payer and DES use; and to examine between- and within-hospital variation in DES use over time.

Methods—We conducted a retrospective analysis of 4.1 million hospitalizations involving DES or BMS from the 2003–2008 Nationwide Inpatient Sample. We estimated hybrid fixed effects logit models and calculated the adjusted within-quarter, cross-payer differences in DES use.

Results—Coronary stent patients with Medicaid or without insurance were significantly less likely to receive DES than were patients with private insurance throughout the study period. The differences fluctuated over time as the popularity of DES relative to BMS rose and fell. The within-hospital gaps paralleled the overall differences, and were largest in Q3 2003 (Medicaid:

*Corresponding Author: University of Pennsylvania School of Medicine, 423 Guardian Drive, 11th Floor, Philadelphia, PA 19104, Tel: (215) 746-7992, Fax: (215) 573-8779, eandrew@mail.med.upenn.edu.

Author Contact Information

Andrew J. Epstein, PhD, MPP, University of Pennsylvania School of Medicine, 423 Guardian Drive, 11th Floor, Philadelphia, PA 19104, Tel: (215) 746-7992, Fax: (215) 573-8779, eandrew@mail.med.upenn.edu

Jonathan D. Ketcham, PhD, Department of Marketing, Box 4206, W.P. Carey School of Business, Arizona State University, Tempe, AZ 85287, Tel: (480) 965-5507, Fax: (480) 965-8000, ketcham@asu.edu

Saif S. Rathore, MPH, Yale School of Medicine, Room IE-61 SHM, 333 Cedar Street, PO Box 2080888, New Haven, CT 06520-8088, Tel: (203) 737-1675, Fax: (203) 785-3461, saif.rathore@yale.edu

Peter W. Groeneveld, MD, MS, University of Pennsylvania School of Medicine, 423 Guardian Drive, 12th Floor, Philadelphia, PA 19104, Tel: (215) 898-2569, Fax: (215) 573-8778, petergro@mail.med.upenn.edu

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

None of the authors had any personal or financial conflicts of interest in regard to this study. The content of this article does not reflect the views of the VA or the US government.

11.9, uninsured: 10.9 percentage points) and Q4 2008 (Medicaid: 12.8, uninsured: 20.7 percentage points), and smallest in Q4 2004 (Medicaid: 1.4, uninsured: 1.1 percentage points). The between-hospital adjusted differences in DES use by payer were small and rarely significant.

Conclusions—We found substantial differences in DES use by payer within hospitals, suggesting physicians selected the new technology for patients in a manner associated with patients' payer type.

Keywords

Variations in care; technology; access

INTRODUCTION

Medical innovation has contributed greatly to increases in longevity, but has also fueled the rapid growth of health care spending.¹ At the same time, prior studies have highlighted the essential role health insurance plays in access to medical care: individuals without any coverage and those with less-generous Medicaid coverage have less access to providers and, even conditional on access, use less medical care than those with Medicare or private insurance.^{2–4} We consider the relationship between insurance and access to innovation in the context of drug-eluting coronary stents (DES), a beneficial but expensive⁵ new medical technology that supplanted the existing technology, bare metal stents (BMS), as the primary device implanted for percutaneous coronary interventions (PCI).

DES make for a particularly interesting case study because their use over the short time they has been available has fluctuated dramatically. DES were initially available outside of clinical trials following FDA approval of the first DES in April 2003. Following randomized trials demonstrating clinical superiority,^{6–7} DES captured 55% of the coronary stent market by the end of 2003 and achieved nearly-complete market penetration by the start of 2005. Rapid adoption occurred despite the absence of favorable financial incentives for providers. Cardiologists were reimbursed the same for DES as for BMS, and hospitals' Medicare profit margins were lower for DES than for BMS.⁸ Patients faced a higher effective price for DES as well; patients receiving DES required a prolonged regimen of clopidogrel, an antiplatelet therapy.

Beginning in 2006, however, research suggested that DES had slightly higher long-term rates of myocardial infarction, death and hospital readmission than BMS.^{9–10} From a peak market share of 90% in August, 2006, DES use declined as providers apparently responded to concerns about DES long-term safety and curtailed off-label DES use.¹¹ In response to the DES safety warnings, recommendations for supplementing DES with clopidogrel were extended from 3–6 months to 12 months or longer.¹² DES use rebounded in 2008,¹³ perhaps due in part to the availability of the first second-generation DES, which showed improved patient outcomes.¹⁴

The history of DES points to several potential sources of differences in DES use by payer type. Studies of medical care disparities suggest they exist, in part, because vulnerable patient populations are treated by lower-quality providers (i.e., between-hospital differences).¹⁵ One reason differences in DES use by payer type might occur is if uninsured and Medicaid patients were treated disproportionately in hospitals that were slower to adopt innovations related to PCI, including DES and new knowledge about DES risks. If so, DES use at these hospitals would have increased more slowly during the initial diffusion period and declined less rapidly subsequent to the safety warnings compared with other hospitals. Similarly, if the hospitals that disproportionately treated uninsured and Medicaid patients had fewer resources or less enthusiasm for high-cost technologies, DES use at these

hospitals would have increased more slowly during the adoption period and decreased more rapidly after the safety warnings.

Alternatively, differences by payer could have arisen from differences in treatment decisions inside the same hospitals (i.e., within-hospital differences). Reimbursement considerations may have prompted hospitals to expand DES use among uninsured and Medicaid insured patients more slowly than others. Also, non-financial factors may have played a role: following the safety warnings, physicians may have placed increased weight on their perceptions of patients' likelihood of adherence, prescription coverage generosity or preferences for a long-term regimen of clopidogrel in deciding whether to use DES. This would have amplified within-hospital differences beginning in mid-2006.

Although prior work has reported lower use of DES among Medicaid and uninsured patients relative to privately insured patients,^{11, 16–20} there has been no investigation of the sources of these payer differences. Our study uses nationally-representative data covering 2003–2008 to better understand overall differences in DES use across payer by separately evaluating the between- and within-hospital sources of variation.

METHODS

We assessed differences across payer types in DES use among patients who received a coronary stent between the initial approval of DES, at the beginning of Q2 2003, through the end of 2008. The payer types we considered were no insurance, Medicaid, Medicare, and private insurance.

Data

We used data from the Nationwide Inpatient Sample (NIS), the largest publicly available all-payer inpatient database in the United States.²¹ It includes administrative records for all hospitalizations in a randomly-selected, national sample of non-federal, acute care hospitals. The 2008 NIS, the most recent version available at the time of the study, contains information on more than 8 million discharges occurring at 1,056 hospitals in 42 states, corresponding to nearly 20% of all admissions to US non-federal hospitals.

Sample

We restricted our analysis to hospitalizations in which the patient had a primary or secondary procedure code indicating the insertion of BMS or DES (*International Classification of Diseases*, 9th Edition Clinical Modification procedure codes 36.06 and 36.07 respectively). We identified 876,480 patient records in the 2003–2008 combined NIS data indicating that coronary stent insertion occurred during hospitalization. To minimize data coding errors, we excluded patient records that were missing data for sex (n=92) or payer (n=1,029) or that were from hospitals with fewer than 5 PCIs coded in the same calendar year (n=163). We excluded patients with rare payer types coded as "Other" (Worker's Compensation, CHAMPUS, CHAMPVA, Title V, and other government programs) (n=23,516). We also excluded records from hospitals that used either all DES or all BMS in a given year (n=1,459), because our methodology requires within-hospital variation in stent type. The final study cohort consisted of 850,221 (97.0%) admissions at 984 hospitals in 41 states.

Measures

The primary study outcome was a dichotomous measure of whether a patient received at least one DES vs. receiving only BMS. We categorized patient payer type into one of four exclusive groups: private (including Blue Cross, commercial carriers, and private HMOs and

PPOs), Medicare (both fee-for-service and managed care), Medicaid (both fee-for-service and managed care), or uninsured (self-pay or charity), based on the coding of the expected primary payer collected in the NIS. Note that Medicare is the primary payer for Medicare-Medicaid dual eligible patients.²² The NIS assigns hospitalizations to calendar quarters based on the date of hospital discharge.

Analysis

Trends in the use of DES were compared on a quarterly basis across payers over the study period. The model capturing the overall quarter-specific differences between payers was specified as:

$$(1) \quad \text{logit}(\text{Pr}[\text{DES}]) = \alpha + \sum_j \beta_j \text{Payer}_j + \gamma \text{Qtr} + \sum_j (\delta_j \text{Payer}_j \times \text{Qtr}) + \theta_1 \text{Patient} + \theta_2 \text{Hospital}$$

where Payer_j is an indicator for whether the patient had insurance type j ($j \in \{\text{Medicare, Medicaid, uninsured}\}$), and Qtr was a vector of 22 calendar quarters (Q2 2003 was omitted). The model specification also included patient-level characteristics (age, sex, race/ethnicity, quartile of median household income of residential ZIP Code, weekend admission, admission severity, transfer from another hospital, indication [acute myocardial infarction, acute coronary syndrome, or neither], and a set of 29 comorbid conditions developed by Elixhauser et al.²³) and hospital-level characteristics (ownership, teaching status, annual PCI volume, Census region, and rural location). We included additional controls for whether the patient was 65 years or older and did not have Medicare, and whether the patient was younger than 65 and did have Medicare.

To quantify the between-hospital and within-hospital differences in DES use across payer types, we specified a hybrid fixed effects model:^{24–25}

$$(2) \quad \text{logit}(\text{Pr}[\text{DES}]) = \alpha + \sum_j \beta_j \text{Payer}_j + \gamma \text{Qtr} + \sum_j (\delta_j \text{Payer}_j \times \text{Qtr}) + \sum_j \rho_j \text{Payer}_{hj} + \sum_j \phi_j \text{Payer}_{hj} \times \text{Qtr} + \theta_1 \text{Patient} + \theta_2 \text{Hospital}$$

This approach adds a measure of the hospital-level proportion of stent patients receiving DES for each payer type (Payer_{hj}) and its interaction with Qtr . In this specification, the patient-level payer indicators capture the within-hospital associations (i.e., the average difference in DES use between otherwise identical patients with different payer types treated at the same hospital), while the hospital-level payer share measures capture the between-hospital associations (i.e., the average difference in DES use between two identical patients treated at hospitals that vary only in the payer mix of their stent patients).²⁶

To facilitate interpretation we converted the logistic regression results to the probability scale. Using the estimated coefficients, we calculated quarter-specific differences in the predicted probability of DES use for each payer type relative to private insurance while holding the remaining covariates at their mean values in the full cohort. For the overall and within-hospital differences, we varied only the patient-level payer indicators in calculating the predicted probabilities. For the between-hospital differences, we varied only the hospital-level payer proportions; in the baseline scenario, they were set to their mean values, and, in the alternate scenario, the hospital-level proportion of the alternate payer type was increased by 10 percentage points while the privately insured proportion was reduced by 10 percentage points from their mean values. We used the Delta method to calculate 95% confidence intervals around these quarter-specific, across-payer differences in predicted probabilities.

Estimation of the logistic regression models incorporated survey weights to account for the complex NIS sampling scheme. As a sensitivity check, to account for the clustering of

patients within hospitals we estimated hierarchical logistic regressions with random intercepts. The results were qualitatively unchanged.

Two-tailed tests with $p < 0.05$ were used to establish statistical significance. Analyses were conducted using Stata 11.2 (College Station, TX). The study was deemed HIPAA-compliant and exempted from IRB review.

RESULTS

Of the 4.1 million hospitalizations involving a coronary stent in the study cohort, most were for patients with Medicare (52.2%) or private insurance (38.5%) (Table 1). Only a small portion of stent procedures involved patients with Medicaid (4.9%) or no insurance (4.4%). Patient and hospital characteristics varied significantly across payer types. As expected, Medicare patients were older on average. Greater proportions of Medicaid patients were female, black, Hispanic, resided in low-income areas, and were admitted to teaching hospitals in the Northeast. Greater proportions of uninsured patients were admitted on the weekend, for non-elective procedures, and to rural hospitals in the South.

Overall Trends in DES Use by Payer

Unadjusted results reported in Figure 1 indicate four distinct time periods in the evolution of the coronary stent market since the introduction of DES. Following FDA approval in April 2003, DES use increased rapidly through the end of 2004. From the start of 2005 through Q2 2006, DES use was stable, with approximately 90% of stent patients receiving at least one DES. After DES safety concerns were publicized, rates of DES use declined sharply between Q3 2006 and Q2 2007, and declined more slowly through the end of 2007. Relative DES use increased starting in Q1 2008. We refer to these four time periods as “adoption” (Q2 2003–Q4 2004), “saturation” (Q1 2005–Q2 2006), “decline” (Q3 2006–Q4 2007), and “resurgence” (Q1 2008–Q4 2008).

This overall pattern held regardless of payer type, but there were differences across payers throughout all four periods. DES use among Medicare patients tracked privately insured patients’ use, but was typically a few percentage points lower. Uninsured and Medicaid patients were less likely to receive DES than privately insured patients throughout, and lagged behind Medicare patients except during the saturation period.

As suggested by Table 1, the unadjusted differences in Figure 1 may be attributable to other patient and hospital characteristics that vary by payer type. We therefore present results that adjust for these characteristics in Figures 2–4, which show the quarterly differences in DES use relative to private insurance (the solid lines) and their 95% confidence intervals (the dashed lines). The underlying data points are provided in the online Appendix.

The overall differences in DES use by payer type remained after adjustment (Figure 2). The adjusted DES rates for both Medicaid and the uninsured were significantly below private insurance for nearly the entire study period. Likewise, Medicare was predominantly below private insurance.

Moreover, Figure 2 shows that differences in rates of DES use by payer type varied over time. During the adoption period, DES use among Medicare beneficiaries was as much as 2.6 percentage points below privately insured patients. In contrast, the deficit was as large as 12.7 percentage points for Medicaid patients and 12.2 percentage points for uninsured patients in Q3 2003. By Q4 2004, the difference with privately insured patients narrowed to roughly 1–2 percentage points for Medicare, Medicaid and uninsured patients. During the saturation period, DES use relative to patients with private insurance remained significantly

lower for Medicare (range: -1.7 to -0.3 percentage points), Medicaid (range: -5.3 to -1.8 percentage points) and uninsured patients (range: -6.4 to -3.0 percentage points). DES use declined among all payer types beginning in Q3 2006, but dropped more quickly for patients with Medicaid or without insurance. The difference in DES use between private insurance and Medicaid patients grew to 11.7 percentage points in Q3 2007 while the gap between privately insured and uninsured patients reached 14.0 percentage points in Q4 2007. Although DES use grew relative to BMS use for all payer types after Q1 2008, the deficit in DES use relative to privately insured patients reached 2.7 percentage points for Medicare, 9.4 percentage points for Medicaid and 16.5 percentage points for uninsured patients by Q4 2008.

Within- and Between-Hospital Differences in DES Use by Payer

The trends in within-hospital adjusted differences in DES use paralleled the overall differences (Figure 3). Rates of DES use among Medicare patients were similar to or slightly lower than use among privately insured patients when treated at the same hospitals through 2006 (range: -1.5 to 1.8 percentage points), but notably lower by Q4 2008 (4.6 percentage points). Medicaid and uninsured patients also received DES at lower rates than privately insured patients at the same hospitals. The within-hospital gaps were largest in Q3 2003 (Medicaid: 11.9, uninsured: 10.9 percentage points) and Q4 2008 (Medicaid: 12.8, uninsured: 20.7 percentage points), and smallest in Q4 2004 (Medicaid: 1.4, uninsured: 1.1 percentage points).

In sharp contrast, the between-hospital adjusted differences in DES use by payer were small and rarely significant (Figure 4). Patients at hospitals with higher shares of Medicaid and uninsured stent patients generally received DES at the same rates as patients at average hospitals. The exception occurred during Q1–Q4 2008, when hospitals treating higher proportions of Medicare patients had significantly higher relative DES use overall. Specifically, during this time, DES use was 2.1 to 3.5 percentage points higher among patients treated at hospitals with a 10 percentage point higher share of Medicare patients (and a 10 percentage point lower share of privately insured patients) relative to hospitals with the mean payer mix.

DISCUSSION

Medicaid and uninsured patients were consistently less likely to receive DES than were privately insured patients during 2003–2008, even after accounting for a range of patient and hospital characteristics. Medicare patients were also less likely to receive DES, though the gap with privately insured patients was smaller. The differences fluctuated over time as the popularity of DES relative to BMS rose and fell. They were large after DES approval, narrowed but were still present as DES use reached saturation, and increased again as DES use declined after safety concerns became widespread in the second half of 2006. By the end of 2008, as DES use climbed again, the gaps grew. Furthermore, variation in DES use by payer was attributable almost entirely to differential treatment within hospitals, and the within-hospital differences were larger in Q4 2008 than at any other time.

Our finding that payer differences in DES use principally reflected intra-hospital differences in treatment is consistent with evidence that hospitals appear to treat cardiovascular patients differently depending on the generosity of their insurance coverage.^{27–28} Further, payer differences in DES use did not stem from Medicaid and uninsured patients' concentrating in hospitals with lower DES usage, ruling out a number of potential explanations and implying that policies aimed at redirecting patients to high-use hospitals would not have ameliorated these differences.¹⁸

Understanding the within-hospital between-payer differences in DES use depends critically on context-specific features. Importantly, physicians receive the same reimbursement for using DES as for BMS.⁸ This equality presumably eliminates their direct financial incentives, which have led to treatment differences in other contexts.²⁹ Even after adjustment for other patient-level demographic and socioeconomic factors, payer type could nevertheless influence physicians' perceptions of patients that in turn affect their choice of stent. One specific concern relates to patient adherence to long-term antiplatelet therapy after DES, which was magnified after the safety warnings in 2006.^{30–33} Physicians may have anticipated that Medicaid and uninsured patients were less likely than privately insured patients to adhere to clopidogrel, perhaps because of perceived or actual differences in patients' out-of-pocket costs or other reasons.

It is also possible that the relationship between payer type and stent choice was shaped by hospitals' financial incentives. Across a range of high-cost drugs and devices known as "physician preference items," there is a well-known misalignment of incentives between physicians, who choose which drugs and devices to use, and hospitals, which bear the cost.³⁴ Hospital acquisition prices for DES have been much higher than for BMS,³⁵ resulting in lower or even negative hospital profit margins for DES for all payer types. Because the margins for DES were even lower relative to BMS for Medicaid and uninsured patients, hospitals may have effectively encouraged cardiologists to concentrate DES use among higher-paying patients, particularly during the early supply shortages.³⁶ Although absent from our data, hospital managers have adopted a number of strategies to influence physicians' device use, including value analysis teams³⁴ and gainsharing.³⁷

Our analysis is limited in two important ways. First, the NIS does not include information on all factors, including clinical data, physicians might consider in selecting stents. As a result, our estimates might suffer from omitted variables bias, and we cannot reach a definitive conclusion about the causes of within-hospital variation in DES use by payer. Also, because the NIS data do not reliably identify physicians, we cannot determine whether the within-hospital differences were created by differences within or between cardiologists.

Second, we cannot say whether differences in DES use imply differences in quality of care. As our data do not identify on- vs. off-label use, we cannot distinguish whether differences reflect under-treatment for some payer types, over-treatment for others, or appropriate care in some or many instances. Given the importance of patient adherence with antiplatelet therapy, however, even with information on clinical appropriateness we could not determine whether a specific patient would have benefited more from DES or BMS. Reasonable physicians might select DES for one patient they thought was likely to adhere to clopidogrel, and select BMS for another patient deemed unlikely to adhere, even if the two patients were otherwise identical.

A broader issue is whether differences in the use of DES by payer type reflect a systemic health care disparity. This depends in part on establishing the incremental value of DES over BMS. Although the principal benefit of DES has been the reduction of restenosis risk, scientific understanding of their risks has evolved even as technology has improved. The value of DES depends on a number of variables and has changed over time, which may be why physicians' perceptions of DES value vary greatly.

Whether our findings indicate a systemic disparity depends also on whether patients with generous insurance are better positioned to accrue the benefits of DES. As suggested by Goldman and Lakdawalla,³⁸ new technologies are likely to exacerbate disparities when they are complicated to use, because more educated and wealthier patients are better able to manage the demands of a complicated treatment and thus will be selected disproportionately

for it. Because DES requires a substantially longer regimen of clopidogrel than BMS, physicians may have limited DES to individuals they thought were more likely to adhere to that regimen, and they may have used payer type as a proxy for adherence. This would explain why the gaps in DES use by payer type grew largest at the end of 2008, as physicians responded to safety warnings and increasingly restricted DES to patients perceived as being clopidogrel-adherent. However, little is known about either the accuracy of clinicians' predictions of long-term medication adherence or whether social factors are reliable predictors of adherence. Data from one center indicate that clopidogrel adherence rates one year post-stent varied little by stent type or payer type.²⁰ Regardless, differences in the use of innovative technologies based on socioeconomic factors like payer type are likely to occur whenever a technology requires physicians to reserve the treatment for patients they judge to have adequate abilities and resources.

During its initial diffusion period and since safety concerns came to light, access to an important new cardiovascular technology differed substantially by payer. Specifically, rates of DES use among the uninsured and Medicaid populations were well below privately insured patients. Although our understanding of the specific mechanisms at work is incomplete, these gaps are almost entirely attributable to differential treatment within hospitals and independent of between-hospital differences. While it does not necessarily follow that physicians based their use of DES directly on patients' payer type, it is unlikely that Medicaid and uninsured patients were less likely than privately insured patients to be clinically appropriate candidates for DES. Thus, the observed differences in DES use across payers likely stemmed from differences in physicians' judgments about patient adherence and/or concerns about hospital finances.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Research support: This research was supported by the National Heart, Lung, and Blood Institute (1R01HL086919) and by the Agency for Healthcare Research and Quality (1R01HS018403).

REFERENCES

1. Bodenheimer T. High and rising health care costs. Part 2: technological innovation. *Ann Intern Med.* 2005; 142(11):932–937. [PubMed: 15941701]
2. Hurley RE, Pham HH, Claxton G. A widening rift in access and quality: growing evidence of economic disparities. *Health Aff.* 2005; 24:w566–w576.
3. McWilliams JM. Health consequences of uninsurance among adults in the United States: recent evidence and implications. *Milbank Q.* 2009; 8(2):443–494. [PubMed: 19523125]
4. Doyle JJ. Health insurance, treatment and outcomes: using auto accidents as health shocks. *Rev Econ Stat.* 2005; 87(2):256–270.
5. Groeneveld PW, Polsky D, Yang F, Yang L, Epstein AJ. The impact of new cardiovascular device technology on health care costs. *Arch Int Med.* 2011 Apr.27 Epub ahead of print.
6. Moses JW, Leon MB, Popma JJ, et al. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. *N Engl J Med.* 2003; 349(13):1315–1323. [PubMed: 14523139]
7. Fattori R, Piva T. Drug-eluting stents in vascular intervention. *Lancet.* 2003; 361(9353):247–249. [PubMed: 12547552]
8. Boston Scientific. [Accessed February 15, 2011] Drug-eluting stent 2009 quick coding and payment reference. 2008 December 8. Available at:

http://www.bostonscientific.com/templatedata/imports/collateral/Reimbursement/Interventional_Cardiology/2009/rmbgde_DES_2009_01_us.pdf.

9. Pfisterer M, Brunner-La Rocca HP, Buser PT, et al. Late clinical events after clopidogrel discontinuation may limit the benefit of drug-eluting stents: an observational study of drug-eluting versus bare-metal stents. *J Am Coll Cardiol*. 2006; 48(12):2584–2591. [PubMed: 17174201]
10. Tung R, Kaul S, Diamond GA, et al. Narrative review: drug-eluting stents for the management of restenosis: a critical appraisal of the evidence. *Ann Intern Med*. 2006; 144(12):913–919. [PubMed: 16785479]
11. Krone RJ, Rao SV, Dai D, et al. Acceptance, panic, and partial recovery: the pattern of usage of drug-eluting stents after introduction in the U.S. *JACC Cardiovascular Interventions*. 2010; 3(9): 902–910. [PubMed: 20850088]
12. Farb A, Boam AB. Stent thrombosis redux—the FDA perspective. *N Engl J Med*. 2007; 356(10): 984–987. [PubMed: 17296827]
13. Epstein AJ, Polsky D, Yang F, Yang L, Groeneveld PW. Coronary revascularization trends in the United States, 2001–2008. *JAMA*. 2011; 305(17):1–8.
14. Stone GW, Rizvo A, Newman W, et al. Everolimus-eluting versus paclitaxel-eluting stents in coronary artery disease. *N Engl J Med*. 2010; 362(18):1663–1674. [PubMed: 20445180]
15. Hasnain-Wynia R, Baker DW, Nerenz D, et al. Disparities in health care are driven by where minority patients seek care. *Arch Intern Med*. 2007; 167(19):1233–1239. [PubMed: 17592095]
16. Kandzari DE, Roe MT, Ohman EM, et al. Frequency, predictors, and outcomes of drug-eluting stent utilization in patients with high-risk non-ST-segment elevation acute coronary syndromes. *Am J Cardiol*. 2005; 96(6):750–755. [PubMed: 16169352]
17. Rao SV, Shaw RE, Brindis RG, et al. Patterns and outcomes of drug-eluting coronary stent use in clinical practice. *Am Heart J*. 2006; 152(2):321–326. [PubMed: 16875917]
18. Hannan EL, Racz M, Walford G, et al. Differences in utilization of drug-eluting coronary stents by race and payer. *Am J Cardiol*. 2007; 100(8):1192–1198. [PubMed: 17920356]
19. Kao J, Vicuna R, House JA, et al. Disparity in drug-eluting stent utilization by insurance type. *Am Heart J*. 2008; 156(6):1133–1140. [PubMed: 19033009]
20. Gaglia MA, Torguson R, Xue Z, et al. Insurance type influences use of drug-eluting stents. *JACC Cardiovascular Interventions*. 2010; 3(7):773–779. [PubMed: 20650440]
21. Agency for Healthcare Research and Quality. [Accessed February 15, 2011] Introduction to the HCUP Nationwide Inpatient Sample (NIS). 2009 June. Available at: http://www.hcup-us.ahrq.gov/db/nation/nis/NIS_Introduction_2007.jsp#table4.
22. Centers for Medicare and Medicaid Services. [Accessed February 15, 2011] Dual eligibility overview. 2009 September 21. <http://www.cms.hhs.gov/DualEligible/>.
23. Elixhauser A, Steiner C, Harris DR, et al. Comorbidity measures for use with administrative data. *Med Care*. 1998; 36(1):8–27. [PubMed: 9431328]
24. Neuhaus JM, Kalbfleisch JD. Between- and within-cluster covariate effects in the analysis of clustered data. *Biometrics*. 1998; 54(2):638–645. [PubMed: 9629647]
25. Allison, PD. Fixed Effects Regression Models. Washington, DC: Sage; 2009.
26. Begg MD, Parides MK. Separation of individual-level and cluster-level covariate effects in regression analysis of correlated data. *Stat Med*. 2003; 22(16):2591–2602. [PubMed: 12898546]
27. Calvin JE, Roe MT, Chen AY, et al. Insurance coverage and care of patients with non-ST-segment elevation acute coronary syndromes. *Ann Intern Med*. 2006; 145(10):739–748. [PubMed: 17116918]
28. Canto JG, Rogers WJ, French WJ, et al. Payer status and the utilization of hospital resources in acute myocardial infarction. *Arch Intern Med*. 2000; 160(6):817–823. [PubMed: 10737281]
29. Gruber J, Kim J, Mayzlin D. Physician fees and procedure intensity: the case of cesarean delivery. *J Health Econ*. 1999; 18(4):473–490. [PubMed: 10539618]
30. Eisenstein EL, Anstrom KJ, Kong DF, et al. Clopidogrel use and long-term clinical outcomes after drug-eluting stent implantation. *JAMA*. 2007; 297(2):159–168. [PubMed: 17148711]

31. Spertus JA, Kettelkamp R, Vance C, et al. Prevalence, predictors, and outcomes of premature discontinuation of thienopyridine therapy after drug-eluting stent placement: results from the PREMIER registry. *Circulation*. 2006; 113(24):2803–2809. [PubMed: 16769908]
32. Jackevicius CA, Tu JV, Demers V, et al. Cardiovascular outcomes after a change in prescription policy for clopidogrel. *N Engl J Med*. 2008; 359(17):1802–1810. [PubMed: 18946065]
33. Philipson TJ, Mozaffari E, Maclean JR. Pharmacy cost sharing, antiplatelet therapy utilization, and health outcomes for patients with acute coronary syndrome. *Am J Manag Care*. 2010; 16(4):290–297. [PubMed: 20394466]
34. Montgomery KS, Schneller ES. Hospitals' strategies for orchestrating selection of physician preference items. *Milbank Q*. 2005; 85(2):307–335. [PubMed: 17517118]
35. Woklhu A, Jollis JG. Dollars and stents: the economics of drug-eluting stents. *Am Heart Hosp J*. 2005; 3(2):94–98. [PubMed: 15864023]
36. [Accessed February 15, 2011] Wall Street Journal Online. Hospital's suspension of Boston Scientific stent gets FDA review. 2005 November 14. Available at: <http://online.wsj.com/article/SB113193228922696123.html>.
37. Ketcham JD, Furukawa MF. Hospital-physician gainsharing in cardiology. *Health Aff*. 2008; 27(3):803–812.
38. Goldman DP, Lakdawalla DN. A theory of health disparities and medical technology. *Contrib Econ Analysis Policy*. 2005; 4(1) Article 8.

Figure 1.
Unadjusted Trends in DES Use by Payer, Q2 2003–Q4 2008.

Figure 2.
Adjusted Overall Differences in DES Use Relative to Private Pay by Payer, Q2 2003–Q4 2008.

Figure 3.
Adjusted Within-Hospital Differences in DES Use Relative to Private Pay by Payer, Q2 2003–Q4 2008.

Figure 4.
Adjusted Between-Hospital Differences in DES Use Relative to Private Pay by Payer, Q2 2003–Q4 2008.

Table 1

Selected Patient and Hospital Characteristics by Payer

	Payer					Overall p
	Total	Private	Medicare	Medicaid	Uninsured	
Patients (N)	4,147,855	1,596,541	2,164,090	204,150	183,074	--
Patients (%)	100.0	38.5	52.2	4.9	4.4	--
Mean Age	64.7	56.6	72.5	55.0	52.8	<0.001
Age						
Age < 65	48.4	86.8	12.5	87.5	93.9	<0.001
Age 65–74	27.5	9.6	44.6	8.4	4.1	
Age 75+	24.1	3.6	43.0	4.1	2.0	
Female	34.1	24.0	41.3	42.0	27.4	<0.001
Weekend Admission	12.8	13.4	11.6	14.8	20.0	<0.001
Admission Type						
Non-Elective Admission	65.0	65.7	62.2	73.8	82.0	<0.001
Elective Admission	34.8	34.1	37.7	26.0	17.7	
Elective Status Missing	0.2	0.2	0.2	0.2	0.3	
Transfer-in Status						
No Transfer In	74.2	74.5	74.9	69.8	67.9	<0.001
Transfer In	12.6	12.4	12.1	15.3	16.0	
Transfer In Missing	13.2	13.0	13.0	14.9	16.2	
Indication						
Acute Myocardial Infarction	35.9	38.9	31.2	39.5	61.4	<0.001
Acute Coronary Syndrome	24.1	23.6	24.9	25.3	19.0	
Other	40.0	37.6	44.0	35.3	19.6	
Selected Comorbidities						
Deficiency Anemias	5.7	3.3	7.6	6.3	3.7	<0.001
Rheumatoid Arthritis/Collagen Vascular Diseases	1.5	1.1	1.8	1.3	0.6	<0.001
Chronic Blood Loss Anemia	0.5	0.3	0.7	0.5	0.3	<0.001
Congestive Heart Failure	10.4	5.5	14.1	11.6	7.5	<0.001
Chronic Pulmonary Disease	13.9	9.4	17.0	19.0	11.3	<0.001

	Payer					Overall p
	Total	Private	Medicare	Medicaid	Uninsured	
Coagulopathy	1.5	1.1	1.8	1.4	1.2	<0.001
Diabetes without Chronic Complications	27.4	24.7	28.9	35.9	24.5	<0.001
Diabetes with Chronic Complications	3.0	2.2	3.6	4.7	1.9	<0.001
Hypertension	67.6	62.9	71.6	69.7	58.5	<0.001
Liver Disease	0.6	0.6	0.5	1.3	0.7	<0.001
Fluid and Electrolytes Disorders	6.0	4.4	7.0	7.1	6.6	<0.001
Obesity	9.3	11.7	7.2	11.9	11.0	<0.001
Peripheral Vascular Disease	9.5	5.8	12.6	8.3	5.0	<0.001
Pulmonary Circulation Disease	1.3	0.7	1.8	1.1	0.7	<0.001
Renal Failure	6.0	2.8	8.6	6.1	2.5	<0.001
Solid Tumor without Metastasis	0.9	0.5	1.2	0.7	0.3	<0.001
Peptic Ulcer Disease × Bleeding	0.03	0.02	0.04	0.05	0.02	<0.001
Valvular Disease	6.3	3.7	8.7	4.0	3.5	<0.001
ZIP Code-level Household Income Quartile						
Quartile 1	24.1	18.1	26.2	40.4	33.0	<0.001
Quartile 2	25.7	24.1	26.6	27.6	27.7	
Quartile 3	24.5	26.6	23.8	18.3	21.8	
Quartile 4	23.4	29.0	21.2	10.8	13.5	
Missing	2.3	2.2	2.2	3.0	4.0	
Race						
White	58.7	58.2	61.4	40.2	51.3	<0.001
Black	5.0	4.4	4.8	9.8	8.4	
Hispanic	4.7	3.7	4.3	12.2	8.4	
Other	4.3	4.5	3.4	10.9	6.2	
Missing	6.4	6.8	6.1	7.8	5.2	
Not Reported by State	20.9	22.5	20.0	19.1	20.4	
Hospital is Rural	4.6	3.7	5.1	5.1	6.2	<0.001
Hospital is Teaching	57.1	57.7	55.9	64.0	57.3	<0.001
Hospital Region						
Northeast	19.9	20.3	19.3	27.8	14.5	<0.001

	Payer					Overall p
	Total	Private	Medicare	Medicaid	Uninsured	
Midwest	25.8	26.8	25.9	20.8	21.5	
South	38.5	35.8	39.6	33.3	54.3	
West	15.9	17.0	15.3	18.3	9.7	
Mean Hospital PCI volume	1,145.3	1,151.3	1,156.8	1,122.6	982.4	<0.001
Hospital PCI Volume						
<400	15.9	16.0	14.8	19.3	23.4	<0.001
400–1,200	47.1	46.4	47.8	44.3	47.1	
>1,200	37.1	37.5	37.4	36.5	29.5	
Hospital Ownership						
Public	8.1	7.3	7.7	10.8	15.7	<0.001
Private Non-Profit	77.4	78.8	77.0	77.3	69.8	
Private For-Profit	13.4	13.0	14.0	10.7	13.1	
Missing	1.1	0.9	1.2	1.2	1.4	
Year						
2003 (Q2–Q4 only)	12.8	12.8	12.8	12.2	10.0	0.005
2004	17.3	17.3	17.2	16.4	16.4	
2005	17.9	17.9	18.1	18.5	16.7	
2006	20.0	20.0	20.2	19.4	19.6	
2007	15.6	15.6	15.4	14.9	17.3	
2008	16.5	16.5	16.2	18.6	20.1	

Source: HCUP Nationwide Inpatient Sample data, weighted to be nationally representative

Note: ZIP Code income quartile cutpoints vary by year (<http://www.hcup-us.ahrq.gov/db/nation/nis/nisdde.jsp>)
Percentages might not sum to 100 due to rounding.