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Variation in Cardiovascular Treatment by Hospital Ownership Type

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Bachelor of Science in Biological Sciences
University of California, Davis
2008

Thesis Committee Chair: Edmund R. Becker, PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
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Abstract

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By Hollis Lin

In recent years, policymakers have placed an increased focus on determining whether non-profit hospitals are providing societal benefits commensurate to their substantial tax benefits and subsidies. A number of recent studies have found that non-profit hospitals provide only marginally more uncompensated care and community benefits than for-profit hospitals, which has led policymakers to question whether the preferential tax treatment of non-profit hospitals is justified.

This study uses the case of drug-eluting stents - an innovative, but expensive, medical technology - to examine whether non-profit hospitals have made trade-offs between improving patient care and increasing profitability. The results of this study will give policymakers a greater understanding of whether non-profit hospitals are using surplus funds to provide improved patient care relative to for-profit and public hospitals.

I analyzed data collected from 2003 to 2010 from the Nationwide Inpatient Sample to assess whether hospital ownership type (i.e. whether a hospital was a for-profit, non-profit, or public hospital) predicted whether or not a patient would receive a drug-eluting stent. I also assessed whether the effect of hospital ownership type changed based on the patient's insurance status. Linear probability models were used to examine these relationships after controlling for relevant patient and hospital characteristics.

I found no evidence that patients who were treated at non-profit hospitals are more likely to receive a drug-eluting stent than those who were treated at for-profit or public hospitals. However, I found that patients who were on Medicaid or were uninsured had a decreased chance of receiving a drug-eluting stent if treated at either a for-profit or non-profit hospital instead of a public hospital. These results leads us to question whether the preferential tax treatment of non-profit hospitals is justified if non-profit hospitals do not provide a higher level of patient care than for-profit hospitals to these vulnerable subgroups.

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Introduction

There has been an ongoing policy discussion about whether non-profit hospitals provide societal benefits commensurate to their substantial federal tax benefits and subsidies; non-profit hospitals receive an estimated $12.6 to $20 billion in benefits from tax-exemption at the federal, state, and local levels every year[1]. In exchange for these benefits, non-profit hospitals are expected to use some surplus funds to improve patient care[2], leading some to argue that current levels of public investment in non-profit hospitals may be justified because non-profit hospitals may provide a higher quality of care than for-profit hospitals[3].

This study uses the case of drug-eluting to assess quality of care along two dimensions: effective care and equitable care. The Institute of Medicine describes effective patient care as service provided based on scientific knowledge, whereas equitable care is consistent patient care regardless of patient characteristics and demographics[4]. Clinical evidence has established that the drug-eluting stent is the more effective technology relative to its predecessor, the bare-metal stent[5]. Previous studies have also found that utilization of the drug-eluting stent has not always been equitable by patient's insurance type[6]. This study uses patient claims data to examine whether non-profit hospitals are providing a higher quality of care with two research questions:

1. Do patients who are treated at public, private, and non-profit hospitals have a different likelihood of receiving a drug-eluting stent?
2. Given that a patient has a certain type of insurance, does his or her likelihood of receiving a drug-eluting stent vary depending on whether he or she is treated at a non-profit, for-profit, or public hospital?

Literature Review

Coronary Heart Disease and Coronary Revascularization Procedures

Coronary heart disease, also known as coronary artery disease, is a narrowing of the small blood vessels that supply blood and oxygen to the heart[7]. Coronary heart disease is caused when fatty materials or other substances form a plaque build-up on the walls of the coronary arteries[7], which restricts the flow of oxygen-rich blood to the heart muscle. If untreated, coronary heart disease can result in angina (chest pain or discomfort), myocardial infarction, and death[8]. For over 80 years, coronary heart disease has been a major cause of disability and the leading cause of death in the United States among both men and women[9]. In 2006, coronary heart disease caused approximately 1 out of every 6 deaths[9].

From 1950 to 1999, the annual mortality rate due to coronary heart-disease declined 59%[10], due in part to the adoption of coronary revascularization procedures[11]. Coronary revascularization procedures, which include coronary artery bypass surgery and percutaneous coronary intervention, are used to unblock or bypass a clogged artery. In 2006, an estimated 1,313,000 inpatient percutaneous coronary interventions were performed in the United States[12]. As of 2010, the percutaneous coronary intervention has become the most frequently performed therapeutic procedure in medicine[13,14].

Percutaneous Coronary Intervention and the Introduction of Bare-Metal Stents

Percutaneous coronary intervention was pioneered in 1979 as a treatment for stenosis (abnormal narrowing) of the coronary artery. During this procedure, the cardiologist feeds a deflated balloon attached to a catheter from the femoral artery into the aorta and eventually into the site of blockage into the heart. From there, the balloon is inflated to dilate the artery and restore blood flow[15]. As the use of this procedure expanded, investigators found a number of complications associated with the procedure, such as abrupt vessel closure and restenosis. Abrupt vessel closure occurred in approximately three to five percent of cases and resulted in myocardial infarction, emergency coronary artery bypass surgery, or death[16]. Restenosis, the re-narrowing of an artery that was previously opened by percutaneous intervention, had an incidence of 25-50 percent during the six months after the procedure was performed[16]. Restenosis is associated with death, myocardial infarction[17], and a repeat hospitalization to unblock or bypass the clogged artery – a process known as revascularization[18].

Coronary stents were first reportedly used in 1987 with the goal of reducing the rate of restenosis and the need for repeat revascularization[19]. These early coronary stents, now called bare-metal stents, are mesh-like metal tubes that are inserted into the artery at the time of the percutaneous coronary intervention; stents hold open the artery after the procedure has been performed to maintain blood flow in the damaged or affected area[15]. Inserting a bare-metal stent during the percutaneous coronary intervention lowered the restenosis rates, but restenosis still developed in as many as a third of patients who were implanted with a bare-metal stent[5,20].

Introduction of Drug-Eluting Stents

Drug-eluting stents were developed with the goal of further reducing the restenosis rate of percutaneous coronary interventions. Drug-eluting stents are similar to bare-metal stents, but have the additional benefit of slowly releasing anti-proliferative agents; these agents prevent restenosis by inhibiting the abnormal growth of tissue following stent implementation[8]. In 2002, a randomized-control trial found that patients treated with drug-eluting stents had a revascularization rate of 5 percent, while those who received a bare-metal stent had a revascularization rate of 28.8 percent[21]. The Food and Drug Administration approved the use of drug-eluting stents in April, 2003 and use diffused quickly despite a lack of favorable financial incentives for providers[6]. Cardiologists were reimbursed the same amount whether they treated a patient with a drug-eluting stent or a bare-metal stent. However, hospitals' Medicare profit margins were lower for drug-eluting stents than for bare-metal stents[6,22]. Nonetheless, drug-eluting stents captured 55 percent of the coronary stent market by the end of 2003 and a peak market share of 90 percent in August, 2006[6].

In 2006, a number of studies found that drug-eluting stent use was associated with late stent thrombosis, which is a rare, but serious and potentially fatal event. Late stent refers to blood clot formation on the stent 30 days to 1 year after implantation and results in a high rate of death and myocardial infarction[8,17]. In March 2006, one study concluded that use of drug-eluting stents was associated with an increase in death or myocardial infarction, potentially related to late stent thrombosis[18]. In September 2006, another study found that drug-eluting stent use was associated with a small, but significant incremental risk of late stent thrombosis[23]. That same month, the Food and Drug Administration issued a statement stating that data suggested a small, but significant increase in the rate of death and myocardial infarction, possibly as a result of stent thrombosis, in patients treated with drug-eluting stents[24]. The FDA called for a 2-day panel session in December, 2006, to fully characterize the risks associated with drug-eluting stents. Based on the conclusions from this session, the FDA released a notification in January, 2007, concluding that drug-eluting stents were safe to use[8,25].

Contemporaneously, a number of researchers found the risks of death and myocardial infarction to be similar, if not lower, among patients who received drug-eluting stents versus bare-metal stents[26]. Stone et al. noted that patients who received drug-eluting stents had a marked reduction in the rate of restenosis, which led to a subsequent reduction in the occurrence of death and myocardial infarction; they argued that the reduction in the risk of death and myocardial infarction from restenosis more than offset the incremental increase risk from stent thrombosis[17]. Other researchers noted the significant incidence of thrombosis, myocardial infarction, and death among patients treated with bare-metal stents and argued that the tendency to increase use of bare-metal stents in place of drug-eluting stents did not ameliorate safety concerns related to coronary stent use [27].

By 2008, drug-eluting stent use had rebounded, which may have been due in part to the introduction of the first second-generation drug-eluting stents[6]. The new generations of drug-eluting stents were developed with the aim of improving safety and efficacy, and have almost completely replaced the old-drug eluting stents[5]. Randomized-control trials demonstrated that new-drug eluting stents have improved clinical outcomes relative to early-generation drug-eluting stents; the newer stents had decreased rates of death, myocardial infarction, repeat revascularization, and stent thrombosis relative to bare-metal stents [28,29]. Subsequently, the risk of stent thrombosis has become exceedingly low and has no longer been a limitation of the use of drug-eluting stents. Clinical evidence has demonstrated superior clinical efficacy and equal safety of drug-eluting stents compared to bare-metal stents since the safety concerns in 2006[18,30–33]. Available evidence supports the use of drug-eluting stents in most clinical settings without safety concerns[5].

Variation in Adoption and Use of Medical Technology by Hospital Ownership

In the context of this study, hospital ownership type refers to public, non-profit, and for-profit hospitals. Public hospitals refer to state and local government owned hospitals; state-owned hospitals include those at state universities whereas locally owned hospitals include county and city hospitals. Federal hospitals, such as those operated by the Department of Veterans Affairs, are not included in this definition. Non-profit hospitals differ from for-profit hospitals because they receive government subsidies and benefits due to their status as charitable organizations as described in 501(c)(3) of the Internal Revenue Code[34]. These benefits include exemption from federal income taxes, eligibility to receive tax-deductible contributions, and authority to use tax-exempt bond financing. In return for these benefits, non-profit hospitals are expected to meet two distinct standards developed by the Internal Revenue Service: the "charity scare standard" and the "community benefit standard." The "charity care standard" requires a hospital to provide, to the extent of its financial ability, free or reduced-cost to patients unable to pay for it. The "community benefit standard" was developed in Revenue Ruling 69-545 and is used to judge hospitals on whether they "promote the health of a broad class of individuals in the community."[2]

Teplensky and Pauly discuss three different perspectives offering different explanations for why hospitals adopt medical technology: profit maximization, technological preeminence, and clinical excellence[35]. The first perspective argues that hospital behavior is linked to anticipated financial returns, so hospitals will adopt a new medical technology if the investment maximizes the profits available to the firm. The second perspective is grounded in the belief that hospitals will adopt new medical technology, no matter the cost, in order to enhance their image as technological leaders. Technically advanced facilities attract patients, administrators, and physicians. Patients frequently associate new technology with high quality of care. Technically advanced hospitals also attract physicians, researchers, and administrators who desire to run a modern institution of high quality and prestige[36]. The third perspective focuses on the provision of needed services, as defined by physicians or the hospital's medical staff. This perspective suggests that hospitals and physicians adopt new technology based on their best determination of the clinical needs of the populations they serve, even if financial, competitive, or prestige considerations suggest alternative actions.

A number of studies have investigated differences in the diffusion of technology between hospitals of different ownership type. Romeo et. al. examined whether government, for-profit, or non-profit hospitals differed in their adoption of five hospital medical technologies; four of the five procedures were clinical in nature, and three of the five were cost-increasing. They found that hospital ownership type did not predict adoption of these medical technologies[37]. Russell examined hospital ownership type on the effect of intensive care technology and found that private, non-profit hospitals were the fastest to adopt. Public hospitals (state and local government hospitals) and for-profit hospitals lagged nearly a year behind[38]. Sloan et al. examined for-profit, non-profit, and public hospitals on their likelihood of adopting new surgical procedures. The authors found that investor-owned (for-profit) and voluntary (private non-profit) hospitals were about equally likely to perform the newer surgical procedure in four out of five instances.

However, public (government-owned) hospitals were consistently less likely to perform the newer procedure than voluntary hospitals[39]. In 2000, Sloan described the literature on hospital ownership type and diffusion of technology as having few well-controlled studies, most of which are now old [40].

Only one study was found to have examined the relationship between profitability of a procedure and the likelihood of hospitals of different ownership type offering that procedure. Horwitz conducted a study that examined the effect of ownership status on its likelihood to offer relatively profitable, unprofitable, or variably profitable services across every U.S. urban, acute care hospital from 1998 - 2000 in the American Hospital Association dataset[41]. Across the 30 services she examined, she found that for-profit hospitals are most likely to offer relatively profitable medical services; government hospitals are most likely to offer relatively unprofitable services; and non-profit hospitals fall somewhere between the two. For-profit hospitals were also found to be more responsive to changes in service profitability than the other two types.

Disparities and Practice Variation in Drug-Eluting Stent Use

A number of studies reported variations in drug-eluting stent treatment across demographic, socio-economic, and hospital characteristics during its early adoption period, from 2003 to 2004. Rao et al. found that patients who were older, Black, Native American, uninsured, and female were less likely to be treated with a drug-eluting stent. They also found that those patients who were treated at hospitals that were: rural; not academic medical centers; or performed a low-volume of percutaneous coronary intervention were less likely to receive a drug-eluting stent[30]. They also identified geographical variations in drug-eluting stent use: patients treated at a hospital on the

West Coast were more likely to receive a drug-eluting stent than patients treated at a hospital in the Great Lakes. Hannan et al. also found that individuals who were African-American, had lower income, and had either Medicaid or no insurance were less likely to receive a drug-eluting stent[42]. Many of these differences in treatment have persisted past the early drug-eluting stent adoption period. As recent as 2008, patients who were Black, uninsured, or on Medicaid were significantly less likely to receive a drug-eluting stent.[6,8,43,44]

Some have suggested that differences in drug-eluting stent treatment can be explained by clinical aspects of the percutaneous coronary intervention. A longer duration of antiplatelet therapy is recommended for patients after the insertion of a drug-eluting stent compared to bare-metal stent patients to prevent the occurrence of stent thrombosis[45]. Subsequently, physicians may have selected bare-metal stents for individuals who are less likely to adhere to the prescribed antiplatelet therapy regimen due to perceived or actual differences in patients' out of pocket costs or other reasons[6]. However, studies have shown that none of the sub-populations who have been identified as being less likely to receive a drug-eluting stent have lower rates of adherence to antiplatelet therapy. Collins et al. found that there is no association between Black or low socio-economic status patients and low compliance with antiplatelet therapy or differences in incidence of stent thrombosis[46]. Gaglia et al. have also found that antiplatelet therapy adherence varied little by stent type or payer type.[43]

Conclusion

The case of drug-eluting stents presents an interesting research opportunity for a number of reasons. The percutaneous coronary intervention is the most frequently performed therapeutic procedure in medicine and treats the leading cause of mortality and one of the leading causes of morbidity in the United States, so utilization of this procedure and technology associated with this procedure has substantial policy implications. The drug-eluting stent has been shown to be clinically superior, but less profitable than the bare-metal stent; this allows us to assess whether hospitals are making trade-offs between effective care and hospital profitability.

Horwitz found that hospitals of different ownership type offered different services depending on the profitability of the service. Epstein et al. suggested that differences in receipt of a drug-eluting stent by payer type may be shaped by hospitals' financial incentives and noted that hospital managers have adopted strategies to influence physicians' device use. Subsequently, hospital managers across hospitals of different ownership types may differentially influence physicians' use of drug-eluting stents, depending on their consideration of their hospitals' financial incentives and the hospitals' stated mission. Together, this research suggests that patients' receipt of a drug-eluting stent may vary based on the patient's insurance type and the ownership type of the hospital at which they are treated. This leads us to question whether hospitals of different ownership type are providing equitable drug-eluting stent treatment to all of their patients with regard to payer type.

This study hopes to contribute to the literature on clinical variation by hospital ownership by addressing two research questions:

Research Question 1: Does the likelihood of a patient receiving a drug-eluting stent vary by hospital ownership type?

Hypothesis 1a: Patients who are treated at for-profit hospitals are less likely to receive a drug-eluting stent than patients treated at either non-profit or public hospitals.

Hypothesis 1b: Patients treated at non-profit hospitals are more likely to receive a drug-eluting stent than patients treated at either for-profit or public hospitals.

Hypothesis1c: Patients treated at public hospitals are more likely to receive a drug-eluting stent than patients treated at for-profit hospitals, but less likely to receive a drug-eluting stent than those treated at non-profit hospitals.

Research Question 2: Prior research has found that payer type predicts whether or not a patient will receive a drug-eluting stent. Does hospital ownership type explain the variation in the receipt of drug-eluting stent by payer type?

Hypothesis: Variation in patient's receipt of drug-eluting stent by payer type can be explained by a hospital's profit status; treatment differences by payer type will persist among for-profit hospitals, but not among non-profit or public hospitals.

Methods

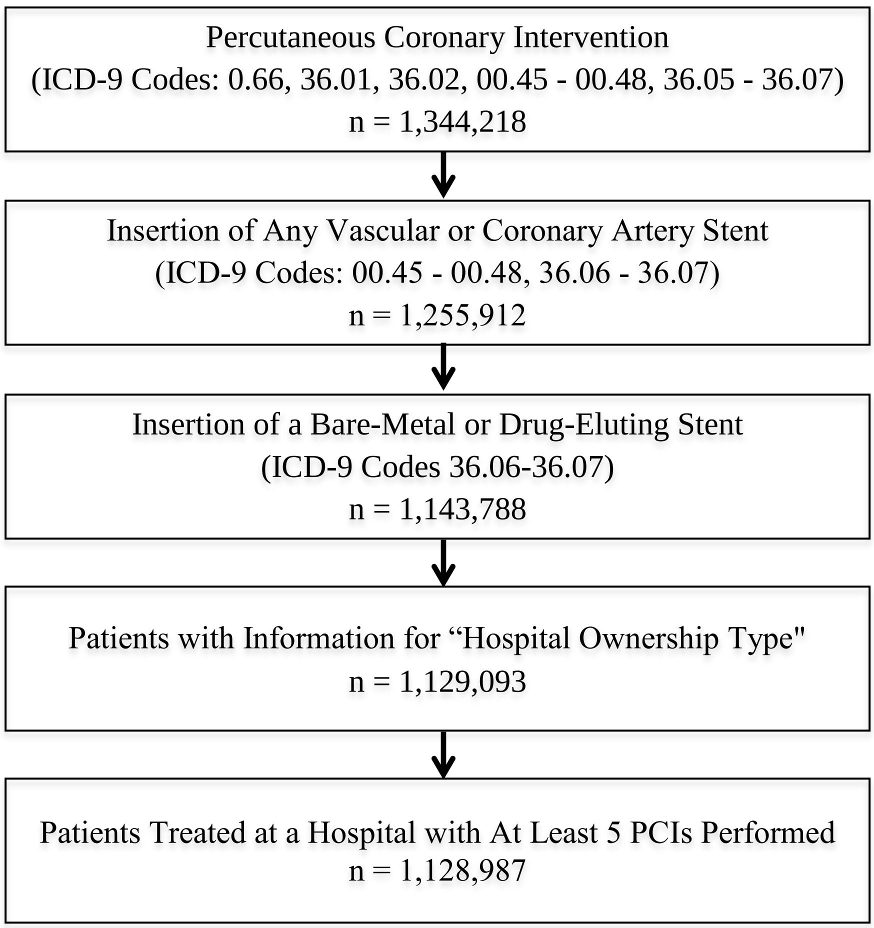
Dataset

This study uses data from the Nationwide Inpatient Sample (NIS), Health Care Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.[47] The NIS is the largest publicly available all-payer inpatient care database in the United States and contains data from approximately 8 million hospital stays each year. The 2010 NIS contains all discharge data from 1,051 hospitals located across 45 states, which approximate a 20-percent stratified sample of U.S. community hospitals. Notably, the NIS does not collect claims data from the same 1,000 hospitals over time, so the NIS has an unbalanced panel of data.

As of 2010, the participating states comprised over 96% of the U.S. population. This study used NIS data from 2003 to 2010. 2003 was the first year that this research question could be studied for two reasons: (1) The Federal Drug Administration approved drug-eluting stents for use in 2003 (2) Drug-eluting stents and bare-metal stents had separate codes in the *International Classification of Diseases, Ninth Revision* (ICD-9) until 2003. 2010 was the endpoint for this study because it was the most recent complete year of data available.

Study Design

This analysis is limited to inpatient hospitalizations in non-profit, for-profit hospitals, and public hospitals from 2003 to 2010. Our sample was subset according to hospital stays that met the following criteria:



Patients were considered to have received the aforementioned procedure if they had a corresponding ICD-9 code for any of their procedures, 1 through 15, in their patient claim. I excluded patients who were treated at hospitals with fewer than 5 percutaneous coronary interventions cases in a given year to minimize observations that may be attributable to coding errors with the claims data. This analysis also controls for all relevant and available demographic and socio-economic patient characteristics as well as relevant hospital characteristics.

Dependent Variable

Patient Received a Drug-Eluting Stent

The outcome variable in this study is a dichotomous measure of whether a patient received at least one drug-eluting versus (corresponding to ICD-9 code 36.06) versus receiving only bare-metal stent(s) (36.07); this measure is identical to the one used by Epstein et al.[6]

Independent Variables

Hospital Ownership Type

This variable was obtained from the American Hospital Association (AHA) Annual Survey of Hospitals[48] and includes four categories: "government, non-federal", "private, investor-owned", "private, not-for-profit", and "missing". The AHA Annual Survey of Hospitals dataset contains separate categorical variables for "state", "county", "city", "city-county", and "hospital district or authority" hospitals within the "government, non-federal" hospital group. However, the NIS collapses these categories into one categorical variable for all "government, non-federal" hospitals, which are also called "public hospitals." "Private, investor-owned" hospitals are referred to as "for-profit hospitals", and "private, not-for-profit" hospitals are referred to as "non-profit hospitals".

Elixhauser Comorbidty Index

The Elixhauser comorbidity index is a set of 29 comorbidities developed by Elixhauser, et al.[49] used for patient risk-adjustment in this analysis. This comorbidity index has been shown to be significantly associated with in-hospital mortality across both acute and chronic conditions and was developed for use with large administrative inpatient datasets. This risk adjustment controls for any patient-level health factors that might lead to physicians choosing to use drug-eluting stents versus bare-metal stents or vice versa. Previous researchers have used the Elixhauser comorbidity index to risk-adjust for patient characteristics that may affect use of cardiac stents.[6]

Patient Age

This analysis controls for patient age, which is calculated from the patient's birth date and the patient's admission date. If the age cannot be calculated, then the value is set to the patient's supplied age. This study separates this variable into three separate categories: "Age 64 and Below, "Age 65 to 74", and "Age 75 and Above." These age bands are identical to the ones used by Epstein et al. so that findings would be comparable.[6] Rao et al. also found differences in the receipt of drug-eluting stents by the patient's age.[30] Theoretically, age may also be a relevant factor that physicians use to decide whether to treat a patient with a drug-eluting or bare-metal stent.

Patient Sex/Gender

This is a dichotomous variable for whether the patient is a female that was obtained from the hospital claim file. Rao et al. found differences in the receipt of drug-eluting stents by patient sex.[30]

Patient Race

The NIS coding includes race and ethnicity in one variable; if the source supplied race and ethnicity in separate data elements, then ethnicity takes precedence over race in setting the value for race. This analysis contains categorical variables for each of the patient race categories: "White", "Black", "Hispanic", "Asian or Pacific Islander", “Native American”, “Other”, and “Missing”. Rao et al. also found differences in the receipt of drug-eluting stents by the patient’s race.[30]

Expected Primary Payer

This variable indicates the patient’s expected primary payer or insurance type. The NIS categories for “Self-Pay” and “No Charge” were combined into a single group for “Uninsured”. This analysis contains categorical variables for each of the following categories: “Medicare, “Medicaid”, “Private Insurance, “Uninsured”, and “Other”.

Elective:

This is a dichotomous variable indicating whether the admission was elective or non-elective. Chan et al. found variation in the use of cardiac stenting between elective and non-elective patients; this variable is included to adjust for possible treatment differences between elective and non-elective patients. Rao et al. also found that emergency percutaneous-coronary interventions have been associated with differentially treatment with drug-eluting versus bare-metal stents.[30]

Median Household Income for Patient’s ZIP Code:

This categorical variable provides a quartile classification of the estimated median household income of residents in the patient’s ZIP code. The quartiles are numbered 1 through 4, indicating the poorest to wealthiest populations. These values are derived from ZIP Code-demographic data estimates that are obtained annually, so the values for these quartiles vary every year. Rao et al. also found that lower income patients were less likely to receive a drug-eluting stent.[30]

Urban or Rural Hospital

This categorical variable identifies whether a hospital is located in a rural or urban location. Before 2004, this information was obtained from the AHA Annual Survey of Hospitals; a hospital located in a Metropolitan Statistical Area was considered urban, whereas hospitals located in non-metropolitan statistical areas were classified as rural. Beginning with the 2004 NIS dataset, the classification of urban or rural hospital location used Core Based Statistical Area (CSBA) codes based on 2000 Census data. Hospitals residing in counties with a CBSA type of "metropolitan" were considered urban, while hospitals with a CBSA type of "micropolitan" or "non-core" were classified as rural. Rao found that patients treated at rural hospitals were less likely to receive a drug-eluting stent.[30]

Teaching Status of Hospital

This is a dichotomous variable indicating whether the hospital was a teaching status; this variable is obtained from the AHA Annual Survey of Hospitals. A hospital is considered a teaching hospital if it has an American Medical Association-approved residency program, is a member of the Council of Teaching Hospitals, or has a ratio of full-time equivalent interns and residents to beds of .25 or higher.

Annual Percutaneous Coronary Interventions

This is a continuous variable for the number of percutaneous coronary interventions a hospital performs in a given year. The NIS is a de-identified data set that has removed data about hospital characteristics, including hospital bed size. This variable is intended to proxy for the bed size or patient volume of the hospital. Physicians at a hospital with a high volume of percutaneous coronary interventions may also be more willing to treat patients with drug-eluting stents because they are more comfortable performing the procedure. This measure was also used by Epstein et al. in examining treatment variations between drug-eluting and bare-metal stents.[6]

Hospital Region

This categorical variable indicates the hospital's census region, as defined by the U.S. Census Bureau, was obtained from the AHA Annual Survey of Hospitals. This variable is included because differences in practice patterns have been shown to vary substantially by region. The four categories included are: "Northeast"," Midwest"," South", and "West". Geographical region has also been associated with differential treatment with drug-eluting stents versus bare-metal stents.[30]

Interactions Terms for Hospital Ownership Type and Payer Type

Categorical variables were also created to assess the interaction between hospital ownership type and payer type. These variables are used to test whether patients with different insurance types differentially receive a drug-eluting stent based on the ownership type of the hospital.

Research Questions and Hypotheses

Research Question 1: Does the likelihood of a patient receiving a drug-eluting stent vary by hospital ownership type?

Hypothesis 1a: Patients who are treated at for-profit hospitals are less likely to receive a drug-eluting stent than patients treated at either non-profit or public hospitals.

Hypothesis 1b: Patients treated at non-profit hospitals are more likely to receive a drug-eluting stent than patients treated at either for-profit or public hospitals.

Hypothesis1c: Patients treated at public hospitals are more likely to receive a drug-eluting stent than patients treated at for-profit hospitals, but less likely to receive a drug-eluting stent than those treated at non-profit hospitals.

Research Question 2: Prior research has found that payer type predicts whether or not a patient will receive a drug-eluting stent. Does hospital ownership type explain the variation in the receipt of drug-eluting stent by payer type?

Hypothesis: Variation in patient's receipt of drug-eluting stent by payer type can be explained by a hospital's profit status; treatment differences by payer type will persist among for-profit hospitals, but not among non-profit or public hospitals.

Data Analysis

This study used two random-effects linear probability regressions. One regression estimated the effect of main effect of hospital ownership type and patient payer type on the likelihood of a patient receiving a drug-eluting stent. The second regression estimated the effect of the interaction of hospital ownership type and payer type on the likelihood of a patient receiving a drug-eluting stent; variables for the main effect of hospital ownership type and patient payer type were omitted. A random-effects model was chosen for three reasons: (1) the NIS does not follow the same hospitals repeatedly over time, so we have an unbalanced panel of data (2) ease of interpretation of results, particularly with interaction terms[50] (3) there was an insufficient sample size of hospitals that changed their hospital ownership type over the study period to conduct a fixed-effects model; only 18 hospitals changed their profit status between 2003 and 2010. Finally, I clustered all standard errors by Hospital Identifier Code because patient treatment may be correlated based on the characteristics of the hospital at which they are treated. All hypotheses were tested at the $\alpha = .05$ significance level.

The following regression model was used to test the hypotheses for the first research question:

Drug-Eluting Stent = $\beta_0 + \beta_1$ *Public Hospital* + β_2 *For-Profit Hospital* $+ \beta_{3-32}$ *Elixhauser* + β_{33} *Age* + β_{34} *Female* + β_{35} *Race* + β_{36} *Payer* + β_{37} *Elective* + β_{38} *Zip-Code Income* + β_{39} *Urban Hospital* + β_{40} *Teaching Hospital* + β_{41} *Annual PCI* + β_{42} *Hospital Region*

The following regression model was used to test the hypotheses for the second research question:

Drug-Eluting Stent = $\beta_0 + \beta_{1-14}$ *Hospital Ownership Type * Payer Type* + $+ \beta_{2-31}$ *Elixhauser* + β_{32} *Age* + β_{33} *Female* + β_{34} *Race* + β_{35} *Elective* + β_{36} *Zip-Code Income* + β_{37} *Urban Hospital* + β_{38} *Teaching Hospital* + β_{39} *Annual PCI* + β_{40} *Hospital Region*

Data management was performed using both SAS and Stata[51,52]. Statistical analysis was performed using Stata[52.] The Emory University Institutional Review Board approved the study as exempt from oversight (IRB00064845).

Results

Descriptive Statistics

Table 1 contains descriptive information regarding the 1,098,214 hospital inpatient stays that were included in the analytical sample. The majority of inpatient stays for coronary stent patients occurred in non-profit hospitals. While 25 percent of the sample contained missing race information, the sample size was still sufficiently large to draw conclusions about differences in drug-eluting stents treatment by race. Table 2 describes the percentage of patients that received a drug-eluting stent as a percentage of all coronary stent patients. Baseline patient characteristics varied on a statistically significant basis by hospital ownership type, with the rare exceptions of certain comorbidities. Figure 1 shows the change in the unadjusted trends in the percentage of patients who received a drug-eluting stent over time. All three hospital ownership types followed the same trend of drug-eluting stent use through the initial drug-eluting stent adoption period from 2003 to 2004, the drug-eluting stent safety concerns from 2006 to 2007, and the re-adoption of drug-eluting stent use from 2007 to the present day.

Table 1: Selected Patient and Hospital Characteristics of Coronary Stent Patients by Hospital Ownership Type

	Public Hospital	Non-Profit Hospital	For-Profit Hospital	Overall *p-value*
Age				
<65	54,766 (9.8%)	430,399 (76.8%)	75,038 (13.4%)	<0.001
65-74	25,719 (8.5%)	233,081 (76.8%)	44,644 (14.7%)	<0.001
74>	20,457 (7.7%)	205,360 (77.4%)	39,523 (14.9%)	<0.001
Female	33,161 (8.7%)	292,852 (76.9%)	54,772 (14.4%)	<0.001
Insurance Type				
Medicare	47,823 (8.4%)	438,901 (77.0%)	83,617 (14.7%)	<0.001
Medicaid	6,705 (11.8%)	43,592 (76.9%)	6,419 (11.3%)	<0.001
Private Insurance	32,178 (7.7%)	328,947 (78.8%)	56,228 (13.5%)	<0.001
Uninsured	8,949 (17.0%)	36,742 (69.7%)	7,061 (13.4%)	<0.001
Other Insurance	4,964 (16.3%)	19,847 (65.3%)	5,567 (18.3%)	<0.001
Race				
White	64,546 (9.6%)	498,254 (73.7%)	113,214 (16.8%)	<0.001
Black	7,261 (11.7%)	45,857 (73.8%)	8,992 (14.5%)	<0.001
Hispanic	6,586 (11.9%)	36,332 (65.4%)	12,603 (22.7%)	<0.001
Asian	2,196 (12.5%)	13,044 (74.2%)	2,331 (13.3%)	<0.001
Native-American	641 (16.3%)	2,203 (56.1%)	1,084 (27.6%)	<0.001
Other	3,809 (13.1%)	20,371 (69.8%)	5,007 (17.2%)	<0.001
Missing	15,903 (5.6%)	252,779 (88.8%)	15,974 (5.6%)	<0.001
Elective Procedure	26,204 (7.2%)	283,734 (77.6%)	55,576 (15.2%)	<0.001
Selected Comorbidities				
Congestive Heart Failure	5,763 (9.4%)	46,759 (75.9%)	9,059 (14.7%)	<0.001
Valvular Disease	2,748 (8.2%)	25,774 (76.5%)	5,163 (15.3%)	<0.001
Pulmonary Circulation Disorders	926 (8.6%)	8,271 (76.8%)	1,578 (14.7%)	0.150
Peripheral Vascular Disorders	9,597 (9.0%)	80,159 (74.9%)	17,191 (16.1%)	<0.001
Hypertension	67,233 (8.9%)	585,372 (77.0%)	107,459 (14.1%)	<0.001
Paralysis	601 (9.3%)	4,987 (77.1%)	881 (13.6%)	0.372
Other Neurological Disorders	2,110 (9.2%)	17,598 (76.8%)	3,222 (14.1%)	0.375
Chronic Pulmonary Disease	14,357 (9.0%)	122,144 (76.6%)	23,034 (14.4%)	<0.001

Diabetes, Uncomplicated	28,497 (9.1%)	240,232 (76.7%)	44,454 (14.2%)	<0.001
Diabetes, Complicated	3,080 (9.3%)	25,478 (76.7%)	4,676 (14.1%)	0.105
Hypothyroidism	6,601 (8.6%)	59,521 (76.8%)	11,280 (14.6%)	<0.001
Renal Failure	7,052 (9.1%)	58,549 (75.8%)	11,608 (15.0%)	<0.001
Liver Disease	888 (11.2%)	5,520 (76.7%)	873 (12.1%)	<0.001
Peptic Ulcer Disease, Excluding Bleeding	24 (6.9%)	288 (82.8%)	36 (10.4%)	0.036
AIDS	154 (14.6%)	787 (74.4%)	116 (11.0%)	<0.001
Lymphoma	271 (8.4%)	2,546 (78.6%)	424 (13.1%)	0.096
Metastatic Cancer	259 (9.0%)	2,254 (78.6%)	356 (12.4%)	0.033
Solid Tumor	841 (8.8%)	7,479 (78.6%)	1,197 (12.6%)	<0.001
Rheumatoid Arthritis/Collagen Vascular Disease	1,505 (8.7%)	13,327 (77.2%)	2,421 (14.0%)	0.555
Coagulopathy	1,630 (.8.9%)	14,045 (76.6%)	2,654 (14.5%)	0.333
Obesity	9.232 (8.1%)	89,201 (78.1%)	15,839 (13.9%)	<0.001
Weight Loss	431 (8.4%)	3,909 (75.8%)	817 (15.8%)	0.001
Fluid and Electrolyte Disorders	6,633 (9.1%)	54,559 (74.9%)	11,667 (16.0%)	<0.001
Blood Loss Anemia	431 (7.8%)	4,250 (76.9%)	849 (15.3%)	0.001
Deficiency Anemias	6,424 (9.0%)	53,648 (75.0%)	11,417 (16.0%)	<0.001
Alcohol Abuse	2,106 (11.8%)	13,431 (74.9%)	2,387 (13.3%)	<0.001
Drug Abuse	1,584 (15.0%)	7,766 (73.7%)	1,187 (11.3%)	<0.001
Psychoses	1,006 (10.2%)	7,358 (74.8%)	1,472 (15.0%)	<0.001
Depression	4,402 (8.9%)	38,427 (78.0%)	6,438 (13.1%)	<0.001
ZIP Code Household Income Quartile				
Quartile 1	31,022 (11.2%)	200,401 (72.3%)	45,928 (16.6%)	<0.001
Quartile 2	28,183 (9.6%)	220,049 (75.3%)	44,063 (15.1%)	<0.001
Quartile 3	22,630 (8.2%)	219,036 (79.3%)	34,628 (12.5%)	<0.001
Quartile 4	15,209 (5.9%)	210,998 (82.3%)	30,200 (11.8%)	<0.001
Urban Hospital	93,912 (8.8%)	821,414 (76.7%)	154,946 (14.5%)	<0.001
Teaching Hospital	54,683 (8.8%)	542,325 (86.8%)	27,716 (4.4%)	<0.001
Year				
2003	13,745 (9.4%)	115,087 (78.5%)	17,835 (12.1%)	<0.001
2004	13,931 (9.4%)	116,286 (78.0%)	18,827 (12.6%)	<0.001

2005	15,384 (10.0%)	116,421 (75.5%)	22,410 (14.5%)	<0.001
2006	13,018 (7.5%)	131,542 (75.6%)	29,431 (16.9%)	<0.001
2007	13,122 (9.9%)	101,296 (76.4%)	18,131 (13.7%)	<0.001
2008	12,756 (8.9%)	110,408 (76.6%)	20,878 (14.5%)	<0.001
2009	9,581 (7.6%)	100,615 (79.8%)	15,951 (12.6%)	<0.001
2010	9,405 (9.2%)	77,185 (75.4%)	15,742 (15.4%)	<0.001
Hospital Region				
Northeast	9,621 (4.5%)	198,046 (92.6%)	6,202 (2.9%)	<0.001
Midwest or Central	8,868 (3.2%)	250,610 (90.6%)	17,198 (6.2%)	<0.001
South	59,774 (13.4%)	288,390 (64.4%)	99,676 (22.3%)	<0.001
West	22,679 (11.9%)	131,794 (69.1%)	36,129 (19.0%)	<0.001
Annual PCI Volume				
<400	24,018 (13.0%)	121,947 (66.1%)	38,536 (20.9%)	<0.001
400-1200	53,896 (10.1%)	389,400 (73.1%)	89,448 (16.8%)	<0.001
>1200	23,028 (5.6%)	357,493 (86.8%)	31,221 (7.6%)	<0.001

Row percentages are reported in percentages (i.e. Percentages across Public, Non-Profit, and For-Profit Hospitals Total 100%)
Source: Nationwide Inpatient Sample 2003 - 2010

Table 2: Selected Patient and Hospital Characteristics of Patients Treated with a Drug-Eluting Stent by Hospital Ownership Type

	Public Hospital	Non-Profit Hospital	For-Profit Hospital	Overall *p-value*
Age				
<65	38,286 (69.9%)	318,436 (73.9%)	54,955 (73.2%)	<0.001
65-74	18,679 (72.6%)	174,746 (75.0%)	32,560 (72.9%)	<0.001
74>	14,348 (70.1%)	144,088 (70.2%)	27,361 (69.2%)	0.001
Female	24,058 (72.6%)	216,073 (73.8%)	39,728 (72.5%)	<0.001
Insurance Type				
Medicare	34,117 (71.3%)	318,905 (72.7%)	59,097 (70.7%)	<0.001
Medicaid	4,362 (65.1%)	30,340 (69.6%)	4,380 (68.2%)	<0.001
Private Insurance	24,059 (74.8%)	249,989 (76.0%)	42,860 (76.2%)	<0.001
Uninsured	5,480 (61.2%)	23,472 (63.9%)	4,239 (60.0%)	<0.001
Other Insurance	3,093 (62.3%)	13,993 (70.5%)	4,113 (73.9%)	<0.001
Race				
White	46,758 (72.4%)	370,001 (74.3%)	80,469 (71.1%)	<0.001
Black	4,823 (66.4%)	32,053 (69.9%)	6,051 (67.3%)	<0.001
Hispanic	4,509 (68.5%)	27,303 (75.2%)	9,383 (74.5%)	<0.001
Asian	1,653 (75.3%)	10,277 (78.8%)	1,754 (75.3%)	<0.001
Native-American	432 (67.4%)	1,709 (77.6%)	777 (71.7%)	<0.001
Other	2,887 (75.8%)	15,585 (76.5%)	3,742 (74.7%)	0.028
Missing	10,251 (64.5%)	180,342 (71.3%)	12,700 (79.5%)	<0.001
Elective	19,500 (74%)	221,892 (77.8%)	41,563 (73.6%)	<0.001
Selected Comorbidities				
Congestive Heart Failure	3,691 (64.1%)	30,115 (64.4%)	5,804 (64.1%)	0.747
Valvular Disease	1,724(62.7%)	17,086 (66.3%)	3,161 (61.2%)	<0.001
Pulmonary Circulation Disorders	568 (61.3%)	5,481 (66.3%)	1,002 (63.5%)	0.002
Peripheral Vascular Disorders	6,649 (69.3%)	58,617 (73.1%)	12,115 (70.5%)	<0.001
Hypertension	48,291 (71.8%)	436,945 (74.6%)	78,415 (73.0%)	<0.001
Paralysis	399 (66.4%)	3,291 (66.0%)	589 (66.9%)	0.875
Other Neurological Disorders	1,401 (66.4%)	12,141 (69.0%)	2,251 (69.9%)	0.022
Chronic Pulmonary Disease	9,827 (68.5%)	86,100 (70.5%)	15,952 (69.3%)	<0.001

Diabetes, Uncomplicated	20,838 (73.1%)	181,244 (75.5%)	32,835 (73.9%)	<0.001
Diabetes, Complicated	2,238 (72.7%)	18,910 (74.2%)	3,386 (72.4%)	0.011
Hypothyroidism	4,875 (73.2%)	44,213 (74.3%)	8,254 (73.2%)	0.013
Renal Failure	4,969 (70.5%)	41,633 (71.1%)	8,169 (70.4%)	0.184
Liver Disease	511 (63.2%)	3,569 (64.7%)	572 (65.5%)	0.612
Peptic Ulcer Disease, Excluding Bleeding	12 (50%)	196 (68.1%)	19 (52.8%)	0.052
AIDS	80 (52.0%)	501 (63.7%)	71 (61.2%)	0.024
Lymphoma	165 (60.9%)	1,717 (67.4%)	284 (67.0%)	0.093
Metastatic Cancer	130 (50.2%)	1,056 (46.9%)	186 (52.3%)	0.121
Solid Tumor	464 (55.2%)	4,110 (55.0%)	676 (56.5%)	0.617
Rheumatoid Arthritis/Collagen Vascular Disease	1,053 (70.0%)	9,590 (72.0%)	1,750 (72.3%)	0.230
Coagulopathy	990 (60.7%)	8,713 (62.0%)	1,682 (63.4%)	0.207
Obesity	6,610 (71.6%)	66,771 (74.9%)	11,370 (71.8%)	<0.001
Weight Loss	247 (57.3%)	2,219 (56.8%)	486 (59.5%)	0.360
Fluid and Electrolyte Disorders	4,271 (64.4%)	35,981 (66.0%)	7,859 (67.4%)	<0.001
Blood Loss Anemia	292 (67.8%)	2,490 (58.6%)	550 (64.8%)	<0.001
Deficiency Anemias	4,292 (66.8%)	36,074 (67.2%)	7,653 (67.0%)	0.741
Alcohol Abuse	1,195 (56.7%)	8,248 (61.4%)	1,484 (62.2%)	<0.001
Drug Abuse	865 (54.6%)	4,347 (56.0%)	673 (56.7%)	0.500
Psychoses	653 (64.9%)	4,924 (66.9%)	945 (64.2%)	0.08
Depression	3,195 (72.6%)	28,608 (74.5%)	4,680 (72.7%)	0.001
ZIP Code Household Income Quartile				
Quartile 1	20,889 (67.3%)	143,964 (71.8%)	31,946 (69.6%)	<0.001
Quartile 2	20,018 (71.0%)	159,668 (72.6%)	31,569 (71.7%)	<0.001
Quartile 3	16,311 (72.1%)	160,492 (73.3%)	25,309 (73.1%)	0.001
Quartile 4	11,404 (75.0%)	159,768 (75.7%)	22,986 (76.1%)	0.030
Urban Hospital	66,850 (71.2%)	604,688 (73.6%)	111,819 (72.2%)	<0.001
Teaching Hospital	37,871 (69.3%)	401,862 (74.1%)	19,890 (72.1%)	<0.001
Year				
2003	4,477 (32.6%)	39,321 (34.2%)	5,636 (31.6%)	<0.001
2004	11,177 (80.2%)	92,839 (79.8%)	14,629 (77.7%)	<0.001

2005	14,018 (91.1%)	106,877 (91.8%)	20,462 (91.3%)	0.002
2006	11,003 (84.5%)	117,795 (89.6%)	24,657 (83.8%)	<0.001
2007	8,743 (66.6%)	70,800 (69.9%)	13,067 (72.1%)	<0.001
2008	8,020 (62.9%)	77,294 (70.0%)	13,190 (63.2%)	<0.001
2009	7,003 (73.1%)	75,735 (75.3%)	11,936 (74.8%)	<0.001
2010	6,872 (73.1%)	56,609 (73.3%)	11,299 (71.8%)	<0.001
Hospital Region				
Northeast	7,898 (82.1%)	150,031 (75.8%)	5,330 (85.9%)	<0.001
Midwest or Central	6,504 (73.3%)	157,713 (70.1%)	11,837 (68.8%)	<0.001
South	40,927 (68.5%)	210,857 (73.1%)	69,245 (69.5%)	<0.001
West	15,984 (70.5%)	100,669 (76.4%)	28,464 (78.8%)	<0.001
Annual PCI Volume				
<400	15,208 (63.3%)	81,445 (66.8%)	26,917 (69.9%)	<0.001
400-1200	38,396 (71.2%)	277,323 (71.2%)	66,912 (74.8%)	<0.001
>1200	17,709 (76.9%)	278,502 (77.9%)	21,047 (67.4%)	<0.001

Column percentages are reported in percentages and reflects the percentage of patients who received a drug-eluting stent of all coronary stent patients

Source: Nationwide Inpatient Sample 2003 - 2010

Figure 1: Unadjusted Percentage of Drug-Eluting Stents as a Percentage of Total Coronary Stents from 2003 – 2010

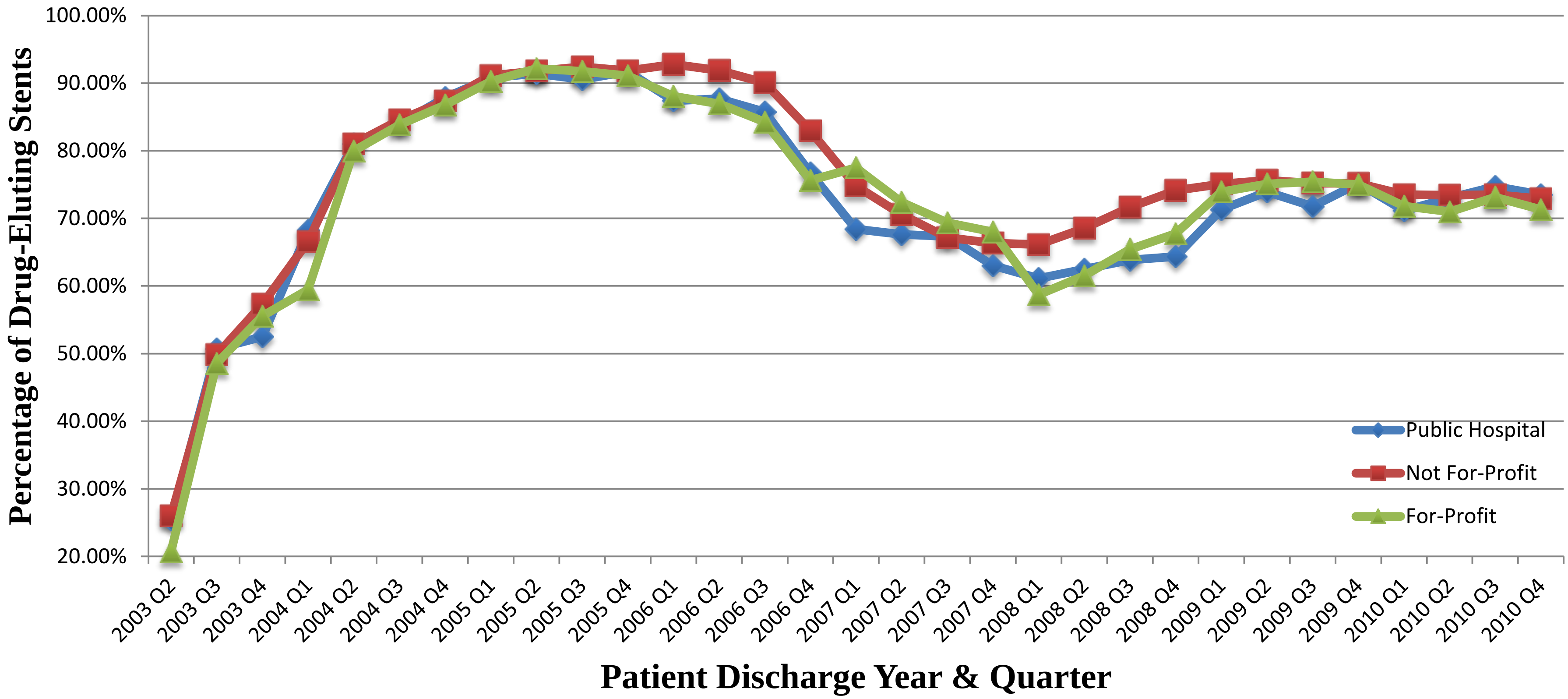


Table 3: Percent Likelihood of Patient Receiving a Drug-Eluting Stent by Hospital and Patient Characteristics

Hospital Ownership Type		
Public Hospital	0.001	(0.038)
Non-Profit Hospital	-0.050	(0.032)
Age		
Age 65-74	-0.0041**	(0.0015)
Age 75+	-0.0428***	(0.0021)
Female	0.0197***	(0.0011)
Insurance Type		
Medicaid	-0.0437***	(0.0033)
Private Insurance	0.0193***	(0.0015)
Other insurance type	-0.0206***	(0.0044)
Uninsured	-0.0924***	(0.0046)
Race		
Black	-0.0253***	(0.0029)
Hispanic	-0.0081**	(0.0031)
Asian or Pacific Islander	0.0110*	(0.0043)
Native American	0.0089	(0.0088)
Other	-0.0013	(0.0042)
Missing	0.0021	(0.0073)
Elective Procedure	0.0508***	(0.0026)
Elixhauser Comorbidity Index		
Congestive Heart Failure	-0.0509***	(0.0030)
Vavular Disease	-0.0386***	(0.0032)
Pulmonary Circulation Disorders	-0.0243***	(0.0064)
Peripheral Vascular Disorders	-0.0072***	(0.0015)
Hypertension	0.0168***	(0.0011)
Paralysis	-0.0415***	(0.0058)
Other Neurological Disorders	-0.0217***	(0.0028)
Chronic Pulmonary Disease	-0.0181***	(0.0012)
Diabetes, Uncomplicated	0.0197***	(0.0011)
Diabetes, Uncomplicated	0.0327***	(0.0027)
Hypothyroidism	0.0081***	(0.0016)
Renal Failure	-0.0154***	(0.0021)
Liver Disease	-0.0592***	(0.0062)
Peptic Ulcer Disease, Excluding Bleeding	-0.094***	(0.027)
AIDS	-0.060***	(0.016)
Lymphoma	-0.0461***	(0.0074)
Metastatic Cancer	-0.228***	(0.0095)
Solid Tumor	-0.159***	(0.0059)
Rheumatoid Arthritis/Collagen Vascular Disease	-0.010**	(0.0033)
Coagulopathy	-0.0697***	(0.0038)
Obesity	-0.0020	(0.0016)
Weight Loss	-0.0851***	(0.0078)

Fluid and Electrolyte Disorders	-0.0385***	(0.0022)
Blood Loss Anemia	-0.0796***	(0.0062)
Deficiency Anemias	-0.0328***	(0.0021)
Alcohol Abuse	-0.0709***	(0.0040)
Drug Abuse	-0.115***	(0.0049)
Psychoses	-0.0415***	(0.0048)
Depression	0.0089***	(0.0020)
ZIP Code Household Income Quartile		
Quartile 2	0.0056***	(0.0016)
Quartile 3	0.0099***	(0.0019)
Quartile 4	0.0172***	(0.0021)
Urban Hospital	0.030	(0.043)
Teaching Hospital	-0.027	(0.019)
Annual PCI Volume	0.000011	(0.000012)
Year		
Year 2003	-0.442***	(0.012)
Year 2004	0.012	(0.011)
Year 2005	0.123***	(0.010)
Year 2006	0.104***	(0.012)
Year 2007	-0.084***	(0.011)
Year 2008	-0.078***	(0.011)
Year 2009	0.0018	(0.0079)
Hospital Region		
Northeast	0.014	(0.018)
Midwest or Central	0.013	(0.014)
West	0.039**	(0.012)
Constant	0.722***	(0.044)
Observations	1098214	
R^2	0.165	

Standard errors in parentheses clustered by Hospital Identifier Code
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Reference Groups: For-Profit Hospitals, Age >65, Medicare, White, Quartile 1, Year 2010, South
Source: Nationwide Inpatient Sample 2003 - 2010

Table 4: Percent Likelihood of Patient Receiving a Drug-Eluting Stent by Interaction of Hospital Ownership and Payer Type

Public Hospitals		
Public * Medicare	0.001	(0.038)
Public * Medicaid	-0.041	(0.039)
Public * Private Insurance	0.017	(0.037)
Public * Other Insurance	-0.032	(0.039)
Public * Uninsured	-0.070	(0.039)
Non-Profit Hospitals		
Non-Profit * Medicare	-0.051	(0.032)
Non-Profit * Medicaid	-0.096**	(0.032)
Non-Profit * Private Insurance	-0.031	(0.032)
Non-Profit * Other Insurance	-0.071*	(0.032)
Non-Profit * Uninsured	-0.144***	(0.032)
For-Profit Hospitals		
For-Profit * Medicaid	-0.0410***	(0.0068)
For-Profit * Private Insurance	0.0172***	(0.0040)
For-Profit * Other Insurance	-0.0135	(0.0087)
For-Profit * Uninsured	-0.113***	(0.010)
Age		
Age 65-74	0.723***	(0.044)
Age 75+	-0.0429***	(0.0021)
Race		
Female	0.0197***	(0.0011)
Black	-0.0252***	(0.0029)
Hispanic	-0.0080**	(0.0031)
Asian or Pacific Islander	0.0110*	(0.0044)
Native American	0.0090	(0.0088)
Other	-0.0012	(0.0042)
Missing	0.0022	(0.0073)
Elective Procedure	0.0508***	(0.0026)
Elixhauser Comorbidity Index		
Congestive Heart Failure	-0.0509***	(0.0030)
Vavular Disease	-0.0386***	(0.0032)
Pulmonary Circulation Disorders	-0.0243***	(0.0064)
Peripheral Vascular Disorders	-0.0072***	(0.0015)
Hypertension	0.0168***	(0.0011)
Paralysis	-0.0415***	(0.0058)
Other Neurological Disorders	-0.0217***	(0.0028)
Chronic Pulmonary Disease	-0.0181***	(0.0012)
Diabetes, Uncomplicated	0.0197***	(0.0011)
Diabetes, Uncomplicated	0.0327***	(0.0027)
Hypothyroidism	0.0081***	(0.0016)
Renal Failure	-0.0154***	(0.0020)
Liver Disease	-0.0591***	(0.0062)

Peptic Ulcer Disease, Excluding Bleeding	-0.094***	(0.027)
AIDS	-0.060***	(0.016)
Lymphoma	-0.0461***	(0.0074)
Metastatic Cancer	-0.228***	(0.0095)
Solid Tumor	-0.159***	(0.0059)
Rheumatoid Arthritis/Collagen Vascular Disease	-0.0100**	(0.0033)
Coagulopathy	-0.0698***	(0.0038)
Obesity	-0.0019	(0.0016)
Weight Loss	-0.0851***	(0.0078)
Fluid and Electrolyte Disorders	-0.0385***	(0.0022)
Blood Loss Anemia	-0.0796***	(0.0062)
Deficiency Anemias	-0.0328***	(0.0021)
Alcohol Abuse	-0.0708***	(0.0040)
Drug Abuse	-0.115***	(0.0049)
Psychoses	-0.0415***	(0.0048)
Depression	0.0088***	(0.0020)
ZIP Code Household Income Quartile		
Quartile 2	0.0056***	(0.0016)
Quartile 3	0.0098***	(0.0019)
Quartile 4	0.0172***	(0.0021)
Urban Hospital	0.030	(0.043)
Teaching Hospital	-0.027	(0.019)
Annual PCI Volume	0.000011	(0.000012)
Year		
Year 2003	-0.442***	(0.012)
Year 2004	0.012	(0.011)
Year 2005	0.123***	(0.010)
Year 2006	0.104***	(0.012)
Year 2007	-0.084***	(0.011)
Year 2008	-0.078***	(0.011)
Year 2009	0.0017	(0.0079)
Hospital Region		
Northeast	0.014	(0.018)
Midwest or Central	0.013	(0.014)
West	0.039**	(0.012)
Constant	.723***	(0.044)
Observations	1098214	
R^2	0.165	

Standard errors in parentheses clustered by Hospital Identifier Code

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Reference Groups: For-Profit Hospitals * Medicare, Age >65, White, Quartile 1, Year 2010, South

Source: Nationwide Inpatient Sample 2003 - 2010

The results in Table 3 show that patients did not differ in their likelihood of receiving a drug-eluting stent by hospital ownership type. Table 4 shows that a number of the interaction terms between payer status and hospital ownership type were statistically significant. Patients treated at non-profit hospitals that had Medicaid, Other Insurance, or were Uninsured had a 5.1, 9.6, and 14.4 percentage point lower chance of receiving a drug-eluting stent relative to Medicare patients treated at for-profit hospitals. Patients treated at for-profit hospitals and had Medicaid or were Uninsured had a 4.1 and 11.3 percentage point lower chance of receiving a drug-eluting stent relative to Medicare patients treated at for-profit hospitals. However, patients with Private Insurance had a 1.7 percentage point higher chance of receiving a drug-eluting stent than Medicare patients treated at for-profit hospitals. Patients who were treated at public hospitals did not have a different likelihood of receiving a drug-eluting stent based on their payer status.

Among the hospital-level covariates, only hospital region was predictive of whether or not a patient would receive a drug-eluting stent. Patients treated in the West census region (which consists of MT, ID, WY, CO, NM, AZ, UT, NV, WA, OR, CA, AK, and HI) were 3.9 percentage points more likely to receive a drug-eluting stent. However, a number of patient-level covariates w.0ere statistically significant: age, sex, payer type, race, and income were all predictive of whether or not a patient would receive a drug-eluting stent

Patients who were 65 years of age or older had a decreased likelihood of receiving a drug-eluting stent relative to patients who were 64 years old or younger. Patients between 65 and 74 years of age and patients over the age of 75 had a 0.4 and 4.3 percentage point decrease in their likelihood of receiving a drug-eluting stent, respectively. Female patients were 2 percent more likely to receive a drug-eluting stent than male patients. Black and Hispanic patients were 2.5 and .8 percentage points less likely to receive a drug-eluting stent, respectively; however, patients who were Asian or Pacific Islander had a 1.1 percentage point higher chance of receiving a drug-eluting stent. Patients who were from households with a higher income were more likely to receive a drug-eluting stent. As a patient's household income increased, so did his or her chance of receiving a drug-eluting stent. Relative to patients with a household income in the lowest quartile, patients in the first, second, and third highest quartiles had a 1.7, .98, and .56 percentage point increased chance of receiving a drug-eluting stent, respectively.

Patients who were Uninsured or on Medicaid had a 9.1 and 4.2 percentage point lower chance of receiving a drug-eluting stent than a patient on Medicare, respectively. Patients who had a payer type of "Other" (e.g. Worker's Compensation, CHAMPUS, CHAMPVA, Title V) had a 2.3 percentage point lower chance of receiving a drug-eluting stent than a patient on Medicare. However, patients who had private insurance had a 1.7 percentage point higher chance of receiving a drug-eluting stents than patients on Medicare.

Discussion

Summary

The first goal of this study was to determine whether patients who were treated at hospitals of different ownership type (e.g. for-profit, non-profit, and public hospitals) had a different likelihood of receiving a drug eluting stent, and the results showed that hospital ownership type was not predictive of whether or not a patient would receive a drug-eluting stent versus a bare-metal stent. The second goal of this study was to determine if patients of a given insurance type had a different likelihood of receiving a drug-eluting stent based on the ownership type of the hospital at which they were treated. The results showed that a patient's insurance type did predict their likelihood of receiving a drug-eluting stent at for-profit and non-profit hospitals, but not at public hospitals. Patients who were Uninsured or were on Medicaid had a lower chance of receiving a drug-eluting stent if treated at either a for-profit or a non-profit hospital relative to Medicare patients at a for-profit hospital. Patients who had an Other Insurance type had a lower chance of receiving a drug-eluting if they were treated at a non-profit hospital. Patients with Private Insurance had an increased chance of receiving drug-eluting stent at a for-profit hospital. There were no differences in treatment by payer type at public hospitals. This indicates that patients who are on Medicaid or are Uninsured are more likely to receive a drug-eluting stent if treated at a public hospital, rather than a for-profit or non-profit hospital.

Contribution to the Literature

The extant literature found some relationships between hospital-level characteristics and the likelihood of a patient receiving a drug –eluting stent[8,30,53], but this study refutes many of these findings when we examine this relationship with more recent, nationally representative data. Using data collected from 2003 to 2004, Rao et al. found that patients who were treated at rural hospitals that performed a low-volume of percutaneous coronary interventions were less likely to receive a drug-eluting stent.[30] However, I found that being treated at a urban or higher volume percutaneous coronary intervention hospital was not predictive of whether a patient would receive a drug-eluting stent. This study does corroborate Rao et al.'s finding that patients who were treated at hospitals in the West are more likely to receive a drug-eluting stent.

Consistent with the extant literature, patient-level characteristics, such as the patient's age, race, insurance type, and income were all statistically significantly associated with a patient's likelihood of receiving a drug-eluting stent. The most recent study to report differences in drug-eluting stent treatment was conducted by Qian et al. using data collected in 2009 in New York State.[8] This is the first study to report differences in drug-eluting stent treatment by demographic or socio-economic factors using nationally representative data since 2006. This study corroborates previous findings that patients who are: older; on Medicaid or are uninsured; or lower income are all less likely to receive a drug-eluting stent. This also corroborates previous findings that female patients are more likely to receive a drug-eluting stent than male patients.

My study also contributes to the literature on variation in the adoption and use of medical technology by hospital ownership type. Prior literature has suggested that hospital ownership type and profitability of a medical procedure predicts the likelihood of that procedure being offered.[41] However, I did not find there was a statistically significant association between hospital ownership type and a patient's receipt of a drug-eluting stent, despite the lack of favorable financial incentives for hospitals to offer a drug-eluting stent. This may be explained by the high demand for percutaneous coronary interventions relative to previous procedures that have been examined. There is a high demand for hospitals to offer percutaneous coronary interventions with a drug-eluting stent due to the high prevalence of coronary heart disease, so hospitals must offer this procedure regardless of its profitability. In contrast, previous procedures have a relatively lower demand, so hospitals may be able to decide whether or not to offer these procedures based on their profitability. This could then lead to variations in the provision of a medical procedure by hospital ownership type. Prior literature on whether or hospital ownership type predicts the adoption of medical technology has been inconclusive.[37–40] While this study does not address medical technology adoption, the variation in drug-eluting stent use across this time span reflects a vacillating trend of adoption, dis-adoption, and re-adoption in use of drug-eluting stents from 2003 to 2010. Subsequently, the results of this study suggest that the adoption of drug-eluting stents did not vary by hospital ownership type.

Policy Implications

Policymakers have been concerned that non-profit hospitals receive substantial federal income tax benefits and subsidies without providing commensurate benefits to society.[54] Some health services researchers have suggested that non-profit hospitals may be delivering a level of community benefit below what would justify current levels of public investment in them because they deliver care that is of higher quality.[3] However, this study suggests that public hospitals may deliver a higher quality of care to Medicaid and uninsured patients than either for-profit or non-profit hospitals, which leads us to question whether the preferential tax treatment of non-profit hospitals is justified. While this finding is only limited to patients who received a coronary stent, this result is significant because the percutaneous coronary intervention is the most frequently performed procedure in medicine and treats the leading cause of mortality in the United States.

Limitations

A number of the limitations of this analysis are related to data constraints from the Nationwide Inpatient Sample. The NIS does not repeatedly sample the same set of hospitals, so it is not possible to track a hospital's adoption of a medical procedure. Subsequently, this study only addresses variation in use by hospital ownership types over time, and cannot issues of technology adoption. The NIS also does not contain information about which hospitals are academic medical centers; as recently as 2009, research has shown that patients treated at academic medical centers are more likely to receive a drug-eluting stent.[8] Lack of information about which hospitals are academic medical centers could confound our estimates of both non-profit and public hospitals' likelihood of treating patients with a drug-eluting stent.

There are also concerns about whether public hospitals, as they are defined in the NIS, generalize to public hospitals across the country. Since the NIS category for public hospitals is a collapsed category of state, city, county, and other hospitals, it is unknown whether the public hospitals in the NIS are comprised entirely academic medical centers at state universities. The NIS also only collects information at the patient and hospital level, not at the physician level; prior research has found that physicians' attitudes about patient safety is predictive of whether a physician chooses to treat patients with drug-eluting stents[8], but this analysis is not able to control for these factors.

Finally, the NIS does not contain any information about whether non-profit hospitals are owned by for-profit entities. There have been an increasing number of mergers and acquisitions of non-profit hospitals by for-profit private equity firms and health systems in recent years, which has led to some concerns that these non-profit hospitals may compromise their mission in favor of profitability.[55,56] This is particularly relevant to this study because drug-eluting stents have a low or negative profit margin across all payer types[6], but are clinically superior to bare-metal stents.[18,30–33] Subsequently, hospital managers in non-profit hospitals owned by for-profit entities may behave more similarly to their counterparts in for-profit than those in independent, non-profit hospitals. This may confound the results of our analysis, considering that hospital managers have adopted a number of strategies to influence physicians' device use in recent years.[6]

Future Research

Future studies should consider linking data from the AHA Annual Survey of Hospitals to the NIS to provide a more reliable estimate of the relationship between hospital ownership type and the likelihood of a patient receiving a drug-eluting stent. This would address many of the limitations from this study, such as missing information about the composition of public hospitals and whether or not a hospital is an academic medical center. This study found that hospital-level factors did not predict whether or not a patient would receive a drug-eluting stent, so additional research should be conducted to determine the role of physician attitudes and behavior in driving such differences.

Conclusion

These results suggest that in the case of drug-eluting stents, non-profit hospitals do not provide a higher quality of care than either for-profit or public hospitals. Instead, the results suggest that public hospitals may deliver a higher quality of care to Medicaid and uninsured patients than either for-profit or non-profit hospitals. This leads us to further question whether the preferential tax treatment of non-profit hospitals relative to for-profit hospitals is justified. The findings of this study also contradict a number of previous findings in the literature using more recent, nationally representative data. Hospital level factors do not predict whether a patient will or will not receive a drug-eluting stent. However, many patient level factors continue to be significant predictors of whether a patient will receive a drug-eluting stent.

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