Multihospital Practice, Patient Injury and Death

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Finally, it's thought that ancient hunters were successful because they could outrun their prey. It was due to endurance, and I have come to see the PhD this way. I have to thank my wonderful parents, brother, Takako and Aki, and Sondra for sustaining me with love and encouragement through this process. I could not have done it without you.

Dedication

This dissertation is dedicated to Alan Hirsch, MD.

Abstract

Physicians often deliver procedures in more than 1 hospital. A consequence of this behavior is the physician has to work with more hospital teams, which reduces the shared experience between physicians and hospitals, limits the availability of physicians before and after procedures, and potentially reduces the mutual investments physicians and hospitals make to improve the quality of their service lines. These factors could increase the risk of medical errors being made during a patient's hospital stay and contribute in other ways to adverse patient outcomes.

The objective of this study is to accurately estimate the relation between multihospital practice by interventional cardiologists delivering percutaneous coronary interventions (PCI) and patient injuries and death following PCI.

I find that multihospital practice holds a significant relation with patient mortality after PCI. Inhospital death rates are 17.3% higher (1.61% to 1.89%; $p < .05$) among physicians most likely to have a multihospital practice (i.e., the highest quartile of predicted multihospital probability) compared to those least likely to (lowest quartile). Evidence suggests that this relation is due to the availability of the physician before PCI, which creates longer times-to-treatment for emergent patients. In addition, I find that physician experience holds an inverse relation with patient injuries due to medical error. Multihospital practice will influence patient injuries from medical error if it substantially changes the physician's procedure experience.

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Chapter 1: Introduction

Physicians often deliver procedures in more than 1 hospital. A consequence of this behavior is the physician has to work with more hospital teams, which reduces the shared experience between physicians and hospitals, limits the availability of physicians before and after procedures, and potentially reduces the mutual investments physicians and hospitals make to improve the quality of their service lines. These factors could increase the risk of medical errors being made during a patient's hospital stay and contribute in other ways to adverse patient outcomes such as inhospital death[1].

Accurate estimation of the effects of multihospital practice on patient outcomes has been difficult for several reasons. First, most research has focused on the implications of multihospital practice at the physician-hospital level, employing a physician's volume in a hospital (or volume share) to test if less frequent relationships are associated with relatively more adverse patient outcomes. These volume based measures are inherently difficult to interpret in patient outcome models due to "selective referral"[2], where higher quality physicians, hospitals, and physician-hospital teams attract more patient volume. Physicians also prefer to work in higher quality hospitals, making it even less clear if practice concentration (i.e., relatively more volume in 1 hospital) actually improves patient outcomes or if physicians admit more patients to their highest quality hospital.

Second, not all physicians practice in multiple hospitals, suggesting there are selective forces pushing some physicians into multihospital practice that could be related to differences in provider quality and patient outcomes. In fact, according to 2 national surveys (Fisher, Staiger, Bynum, & Gottlieb, 2007; Miller, Welch, & Welch, 1996), 40%

[1] The number of deaths resulting from medical errors is not precisely known, but recent estimates peg medical error as the third leading cause of death in the United States after heart disease and cancer (Makary & Daniel, 2016).

[2] Luft, Hunt, and Maerki 1987 describe the influence of selective referral on the volume-outcome relation.

of all physicians worked in multiple hospitals. Prior research has not investigated why some physicians decide to practice in multiple hospitals, and the effects of this choice on patient outcomes have not been explored as a physician-level characteristic.

My dissertation examines the implications of physicians practicing in multiple hospitals (i.e., multihospital practice) on patient injury and death following percutaneous coronary interventions (PCI). I explore this relation using a 100% sample of Fee-For-Service (FFS) Medicare claims for patients that received PCI over the period 2001 through 2004. This population constitutes a substantial portion of all patients undergoing PCI in any year and, due to its national presence, offers insight into how multihospital practice influences inpatient mortality across PCI hospitals in the United States. Because unobserved factors like physician quality differences directly impact adverse outcome rates and may influence the decision to practice in more than 1 hospital, I employ an instrumental variables approach to estimate the effect of multihospital practice on patient injury and death.

The dissertation proceeds as follows. In chapters 2 through 4, I review the literature, describe my study setting, and introduce the data. In chapter 5, I document regional variation in multihospital practice among interventional cardiologists delivering PCI over my study period. Then, chapters 6 through 8 present my analysis on the relation between multihospital practice and patient injury and death, which proceeds in two stages: first, developing an exogenous measure of multihospital practice, and second, estimating the relation between my exogenous measure and the occurrence of patient injuries and mortality following PCI. Chapter 9 summarizes the findings of my dissertation.

Chapter 6 describes the first stage of my analysis, which is a model of the physician's decision to practice in multiple hospitals. My approach is as follows: first, I construct physician market areas as the 25 miles around a physician's zip. Second, I exploit differences in the presence and spatial proximity of PCI hospitals within and across physician market areas over my study period—from 2001 through 2004—to predict whether physicians performed PCI in more than 1 hospital in a given year.

This first stage model, estimated at the physician-year level with a physician fixed-effect, uses four instrumental variables: first is a measure of the average of the bilateral distances between each pair of large PCI hospitals (which I define as hospitals with ≥ 40 PCI per year[3]) within a market. Physicians are more likely to be multihospital when PCI hospitals in their markets are located closer together. Second, I include an indicator for whether the physician's market has at least 1 PCI hospital (which I define as hospitals with ≥ 10 PCI per year) to separate out markets without any PCI hospitals. Third, I include a categorical variable measuring the number of small PCI hospitals (<40 PCI per year) in the physician's market—hospitals where PCI is delivered infrequently—because in such markets physicians are more likely to find part-time opportunities in secondary hospitals. Fourth, I include a categorical variable for the number of large PCI hospitals (≥ 40 PCI per year) in the market, where multihospital practice becomes more likely when more large hospitals divide the market's PCI volume. Taken together, the

[3] FFS Medicare made up approximately 40% of the entire PCI market during this period (McGrath, 2000). Hospitals with 40 Medicare PCI per year probably delivered 100 PCI overall, which would be sufficient volume for 1 full-time PCI physician according to guidelines at the time (Smith et al., 2001).

first stage model shows that these instruments strongly predict the probability a physician will be multihospital in a given year in the expected direction.

Chapter 7 describes the second stage models, which are patient outcome models (at the patient level) of whether the patient was injured during their hospital stay, or whether they died in the hospital (inhospital death) or soon after (10 or 30 days) their PCI. The sample includes PCI patients that were admitted with a primary diagnosis of atherosclerosis or AMI—the 2 conditions most associated with PCI. The key explanatory variable is the instrumented measure of whether the physician performing the PCI is multihospital or not during the year of the PCI. I include quartiles of the predicted probability of multihospital practice from the first stage described above. The model also adjusts for patient, physician, and hospital characteristics believed to influence patient injury and mortality like the physician's PCI volume in a patient's hospital. To further control for unobserved time-invariant differences between regions and hospitals that might invalidate my instruments, I estimate two fixed effect models: first, I include fixed effects for the physician's hospital referral region (HRR) to account for unobserved regional differences, and second, I include hospital fixed effects for the patient's hospital to more completely control for unobserved quality differences between PCI service lines.

In addition, my instruments could be interpreted as proxies for inter-hospital competition which might have a direct effect on quality and patient outcomes. To control for this influence, I include a direct measure of PCI hospital competition within the physician's market in my second stage outcome models. In the Medicare FFS market, where prices are administered[4], hospital quality indeed has been shown to be superior in more competitive hospital markets (Gaynor & Town, 2012). To control for hospital

[4] Without the ability to compete on prices, hospitals compete on quality to attract FFS patients.

competition in a way that is unrelated to unobserved determinants of hospital quality and patient outcomes, I estimate annual measures of PCI hospital demand based on distances from patient residence to PCI hospitals. I use the predicted hospital demands within each physician's market to form instrumented measures of hospital market structure, which are instrumented Herfindahl-Hirschman Index (HHI) values, and I include indicators for each quartile of instrumented HHI (from the most competitive markets to the least) in my outcome model to control for changes in the level of PCI hospital competition within physician market areas.

Similarly, my instruments could be interpreted as a proxy for lack of experience performing PCIs which also could affect quality and patient outcomes. Again, however, I include direct measures of both the physician's and hospital's total PCI volume in my second stage mortality model, allowing the HRR or hospital level fixed effect to pick up the remaining explainable variation in quality and patient outcomes associated with low volume PCI hospitals, i.e., the need for the physician to practice in more than one hospital.

In chapter 6, I find that physicians with the lowest probability of multihospital practice were located in markets with 1 large PCI hospital (≥40 PCI per year) and 0 small PCI hospitals (<40 PCI per year). Physicians with the highest probability of multihospital practice were located in markets with 4 or 5 large PCI hospitals in close proximity, with an additional 3 or more small PCI hospitals within the market boundary (i.e. 25 miles in any direction). Jointly, the instruments I used are strongly predictive of multihospital practice.

In chapter 7, I find that patient injury is significantly related to physician experience. More PCI volume in a patient's hospital is associated with lower risk of injury from medical error. However, patient injuries are not related to whether the physician is multihospital or not. Unless a physician's PCI volume is affected by multihospital practice, there appears to be no additional difference in patient injury risk between solo-hospital physicians and multihospital physicians.

In my patient mortality models, I find the opposite result: physician experience is unrelated to mortality, but multihospital practice holds a significant relation with patient mortality after PCI. I find that inhospital death rates are 17.3% higher (1.61% to 1.89%; $p < .05$) among physicians most likely to have a multihospital practice (i.e., the highest quartile of predicted multihospital probability) compared to those least likely to (lowest quartile), suggesting that multihospital practice increases inpatient mortality though other mechanisms than familiarity (i.e. physician-hospital volume).

Compared to the instrumented results, I find that without instrumenting for multihospital practice (where unobserved factors are not accounted for) there is no significant mortality difference between multi and solo-hospital physicians. The contrasting results indicate there is favorable selection into multihospital practices that biases uncorrected results toward finding no detrimental effect. One possibility is this occurs through unobserved patient severity: unhealthier patients are selecting into solo-hospital practices, while healthier patients are selecting into multihospital practices. Another possibility is that higher quality physicians or hospitals select into multihospital practices and out-perform physicians and hospitals that do not. While my design does not allow me to identify the source of the selection bias with certainty, observed differences in patient characteristics between solo and multihospital physicians indicate that solo hospital physicians see more emergent PCI patients suffering from heart attacks and multihospital physicians see more elective patients suffering from less acute conditions. This descriptive evidence suggests that unobserved patient severity is one source of selection bias.

In chapter 8, I investigate whether the availability of the physician before PCI (and possibly after discharge) could explain the relation between multihospital practice and patient mortality I find in chapter 7. If a physician is not in a patient's hospital when the patient shows up (i.e., they're not available before the PCI), then the hospital will need to call the physician to the hospital to deliver the procedure. This creates additional risk when the patient's condition is sensitive to the time-to-PCI (a.k.a., time-to balloon), as would be the case for primary PCI delivered to heart attack patients. Multihospital physicians that have a "primary" hospital (i.e., where they do most of their work) and "secondary" hospitals (i.e., other hospitals they work in less often) are more likely to be called-in to their secondary hospitals and will be more likely to create longer times-to-balloon for their emergent PCI patients in secondary hospitals.

I find that no mortality difference exists between physicians' primary and secondary hospitals on days they worked in only 1 hospital. On days they worked in more than 1 hospital, I find that adjusted 10 day mortality is 32% higher in secondary hospitals compared to primary ones. Adjusted 10 day mortality after PCI is 2.21% in their secondary hospitals compared to 1.67% in their primary hospitals. While not definitive, these estimates would support the theory that the availability of the multihospital physician before PCI (and possibly after discharge) creates the mortality difference observed in chapter 7.

Chapter 2: Literature Review

What is known about multihospital practice and its effect on patient outcomes has come from the physician-hospital concentration literature. I briefly review the evolution of this literature and describe how my dissertation contributes to it.

Physician-Hospital Concentration Literature

The physician-hospital concentration literature traces its origins back to theoretical (Roemer & Friedman, 1971) and empirical (S. M. Shortell & Getzen, 1979) typologies of hospital medical staff organization. This work was largely concerned with comparing the performance of hospitals staffed by physician employees with open staff hospitals. These typologies had multiple features, including the physician appointment procedure and medical staff governance. Their authors believed that physician commitment was the most important feature in the typology effecting patient outcomes. Commitment represented the degree of involvement the hospital had in the professional life of the physician. The authors conjectured that hospitals would be more effective in achieving organizational goals like quality improvement when it played a larger role in a physician's practice. Embedded in this argument was the idea that the potential loss of using the hospital, which would be the loss of the physician's business, bound the physician and the hospital together and made them more effective at improving care.

Early empirical evidence supported this. In a pair of articles (Flood & Scott, 1978; Flood, Scott, Ewy, & Forrest, 1982) from the late 1970s, researchers found that surgical outcomes were better than expected when the share of a physician's practice at the hospital was higher. In another study (S. Shortell & LoGerfo, 1981), researchers found that the removal of healthy tissue during appendectomies was less when the physician concentrated more of their practice in a patient's hospital. In addition to commitment, the authors conjectured that more consistent monitoring from peers, which would happen when physicians concentrated their practice in a hospital, improved physician performance.

Other empirical research from this period showed that concentration of practice likely played a role in hospital utilization as well. One study found that infrequent users of a hospital were associated with higher costs per admission (MV Pauly, 1978). The author conjectured that physicians face a higher transaction cost when they work in secondary hospitals (i.e., not their primary hospital) because most of their practice is located elsewhere. In order to spend the least amount of time in secondary hospitals, physicians substitute other hospital resources (e.g., tests, other hospital staff) for their own time in the hospital supervising the patient's care.

The introduction of prospective payment in the 1980s motivated more research in this area. Prospective payment changed the way hospitals were paid. Instead of receiving compensation for the quantity of services delivered, hospitals were now paid a fixed price per admission. While physicians continued to be paid on a quantity basis, hospitals were now incentivized to be efficient in delivering an inpatient admission. This now placed physicians and hospitals at odds incentive wise (Glandon & Morrisey, 1985) and motivated new research into the admitting decisions of physicians.

This research showed that multihospital practice and hospital concentration has been a consistent and stable feature of medical practice in the United States. In general, close to 40 percent of physicians work in multiple hospitals in a given year and they concentrate 90 percent of their practice in their primary hospital[5]. Some specialties multihospital practice more than others, and urban locations tend to see more of it. One study (L R Burns, Wholey, & Huonker, 1989) showed that younger physicians were more likely to multihospital practice, and physicians located in areas with more HMO market share were less likely to multihospital practice.

In a set of studies (L. Burns & Wholey, 1992; L R Burns et al., 1989; Wholey & Burns, 1991) of physician admitting behavior from the early 1990s, researchers showed that physicians tend to work in hospitals that were convenient to their offices. The convenience of the hospital's location and the hospital's available resources (e.g., beds, specialists, services) were the most relevant factors in explaining physician admitting behavior. These studies also showed that physician admitting behavior is relatively stable over time. They calculated that it would take 6 years (on average) for a physician to fully transfer their admissions out of one hospital location and into another (Wholey & Burns, 1991).

These researchers also evaluated the effect of practice concentration on length of stay (a proxy for resource use) and patient outcomes (L. Burns & Wholey, 1991), finding different effects for medical and surgical admissions. More concentrated physicians had lower lengths of stay for medical admissions, but higher lengths of stay for surgical admissions (which they showed again for obstetric patients in another related article (L. Burns, Chilingerian, & Wholey, 1994)). And greater concentration lowered the risk of

[5] In 1977 physicians held admitting privileges to an average of 2.4 hospitals and sent 89 percent of their admissions to their primary hospital location (Gaffney & Glandon, 1982). In 1992, physicians worked in an average of 1.56 hospitals (which included 62 percent of physicians who worked in only 1 hospital), and sent 90 percent of their admissions to their primary hospital (Miller et al., 1994). In 2003, 62 percent of physicians worked in only 1 hospital and physicians with hospital work sent 90.1 percent of their admissions to their primary hospital (Fisher et al., 2007).

inhospital mortality for 2 of 5 surgical procedures, but raised the risk of death for 2 of 11 medical conditions.

In a study from 1996 (Miller et al., 1996), researchers investigated the relation between inpatient utilization of resources and the number of hospitals a physician worked in over a 6 month period in 1991. The authors used RVUs per hospital stay as their measure of inpatient utilization, something they called the physician profile, and quantified the number of hospitals the physician admitted to over their study period. The authors showed that a monotonic-like pattern of RVU escalation existed when physicians incrementally added additional hospitals, finding that physicians who work in 1 hospital are 2.1 percent below the mean RVU profile, physicians in 2 hospitals are 2.3 percent above the mean profile, 3 hospitals are 4.5 percent above, 4 hospitals are 8.2 percent above, and 5 or more hospitals are 11.5 percent above the mean profile. They argued that the pattern demonstrated a dose-response effect, whereby physicians respond to a dose of one more hospital by increasing their inpatient utilization profile. Like earlier work (MV Pauly, 1978), the authors conjectured that physicians are more likely to substitute other hospital resources for their own labor when their work becomes more dispersed across hospitals.

More recent work in this literature has returned the focus to the effect of physician-hospital concentration on patient outcomes, building off the well-known volume-outcome relation (Halm, 2002; H. S. Luft, Bunker, & Enthoven, 1979). This work has been motivated by the evolving role of payment reform in incentivizing care quality (Fisher et al., 2007) and the belief that fragmented care between physicians and hospitals creates more opportunities for medical errors—mistakes that can lead to adverse outcomes like patient injury and death. The mechanism connecting the two is familiarity: medical errors are less likely when the physician is more familiar with a hospital's resources (e.g., staff, equipment, process of care). One study showed that a physician's volume in a specific hospital was significantly related to lower mortality following CABG surgeries in that hospital, while their volume in other hospitals was not (Huckman & Pisano, 2006). This work showed that the volume-outcome relation is "firm-specific". Other studies supported this finding: high volume physicians were found to be as effective as low volume physicians in hospitals they used less often (Carey, Parker, Brandeau, & Li, 2008), and instrumented firm-specific volume was found to be inversely related to patient mortality following CABG (Ramanarayanan, 2008). Most recently, "provider fit" with a hospital was found to matter by evaluating if unique physician-hospital team effects held a significant relationship with variation in patient outcomes (Huesch, 2011).

Contribution to the Literature

My dissertation makes several contributions to the literature. It joins a set of studies that go back decades on the relation between physicians' practice concentration in hospitals and patient outcomes (L. Burns & Wholey, 1991; Fisher et al., 2007; Flood & Scott, 1978; Flood et al., 1982; S. Shortell & LoGerfo, 1981), and a growing literature on the "firm-specificity" of the volume-outcome relation (Carey et al. 2008; Huckman and Pisano 2006). The earlier findings in this literature did not correct for the influence of selective referral: higher quality physicians, hospitals, and physician-hospital teams attract more patient volume. Without correcting for this influence, the findings in this literature have been difficult to understand. Though, a more recent study that instrumented for physician-hospital volume (Ramanarayanan, 2008) found that higher physician-hospital volume was associated with better patient outcomes. My study confirms some of the findings in this prior literature and adds to them by identifying physician availability before and after procedures as a plausible mechanism for why multihospital practice is related to patient outcomes like patient mortality. Also, my study shows favorable selection into multihospital practices, suggesting that prior research has probably understated the detrimental effects of working in multiple hospitals on patient outcomes.

My paper joins a small literature on the determinants of where physicians practice. Prior research (L. Burns & Wholey, 1992; L R Burns et al., 1989; Wholey & Burns, 1991) demonstrated that physicians tend to work in convenient hospitals (near their office) with more resources (e.g., beds, specialists, services). In another study, (David & Neuman, 2011) found that physicians who worked in the state where they completed their hospital residencies were more likely to practice in more than 1 type of outpatient care setting: hospital based outpatient departments and ambulatory surgical centers. My study adds to this literature by uncovering market level factors that influence the decision to practice in more than 1 hospital.

My study joins a literature in health outcomes research that employs instrumental variables to identify relations in secondary data (Newhouse & McClellan, 1998). Prior studies have used patients' distances to hospitals to instrument for observed patient flows and hospital market structure (Gowrisankaran & Town, 2003; Kessler & McClellan, 2000). My study joins this literature by developing a set of new instruments for the presence and spatial proximity of hospitals within a physician's market that are predictive of multihospital practice but plausibly unrelated to patient outcomes with the addition of region or hospital fixed effects.

Finally, my study joins a larger literature on the effects of market characteristics and hospital market structure on firm performance and physician behavior. In general, hospital markets have been found to be higher quality when there is more competition (Gaynor & Town, 2012), especially when hospitals can't compete on prices. And hospital competition has been found to influence physician admitting behavior (Hughes & Luft, 1991; H. Luft, Robinson, & Garnick, 1986). "Thicker" markets are believed to have deeper labor pools and superior firm-employee matches (Moretti, 2011), as would be the case in more competitive hospital markets. Recent studies in the urban economics literature suggest that agglomeration economies exist in markets with clustered hospitals (Cohen & Morrison Paul, 2008; Li, 2013), with some evidence suggesting a favorable influence on patient outcomes (Li, 2014). While other studies suggest some markets are too clustered for achieving the best health outcomes (Sheppard & Hellstern, 2014). My dissertation shows that a consequence of more hospitals in a market is multihospital practice. And for PCI, multihospital practice is associated with higher mortality rates, likely stemming from the availability of the physician before and after procedures.

Chapter 3: Study Setting

My dissertation explores the effects of multihospital practice among interventional cardiologists delivering PCI. In this chapter I describe PCI and changes in the PCI market over the 1990s and early 2000s (my study setting is 2001 through 2004). PCIs are delivered by interventional cardiologists in hospital catheterization laboratories (cath labs). Interventional cardiologists are known to “split” their practices between multiple hospitals (Lawton Robert Burns & Muller, 2008), and there is a substantial literature documenting the role of operator and hospital competency in PCI outcomes like inpatient death (Harold et al., 2013) making it an appropriate procedure to evaluate the effects of multihospital practice..

PCI is a hospital procedure delivered to patients suffering from atherosclerosis in their coronary arteries (a.k.a. coronary heart disease (CHD)). Patients diagnosed with CHD have excessive plaque built up in at least 1 of their coronary blood vessels[6]. This condition constricts the flow of oxygen to the various working parts of the heart, disrupting the heart’s normal functions and causing a variety of symptoms like angina (chest pain) and shortness of breath. When vessels become completely occluded, the patient experiences an acute myocardial infarction (AMI) (a.k.a. heart attack), where the heart begins to die. CHD remains the leading cause of death in the United States and is a major cost of medical care, totaling almost $200 billion dollars in direct and indirect costs in 2009 (Go et al., 2013).

[6] There are 2 main arteries in the heart: the right coronary artery, and the left coronary artery. The left artery branches into 2 sub-vessels: the circumflex artery and the left anterior descending artery. Medicare HCPCS modifier codes allow the performing physician to indicate if the PCI involved the right, left circumflex or left descending vessel. If the PCI involved more than 1 vessel (a.k.a. multivessel PCI), then the physician is paid ½ the regular rate for each extra vessel.

Treatment for CHD depends on the severity of the patient's condition. If the patient's arteries are not sufficiently occluded, then lifestyle changes such as diet and exercise can be used to manage their condition (a.k.a., medical management). If their arteries are sufficiently occluded, then patients can obtain a PCI or coronary artery bypass grafting (CABG) to restore normal blood flow to their heart. CABG (a.k.a., open heart surgery) is a major hospital procedure performed by cardiothoracic surgeons where a new vessel is constructed around the damaged one using tissue transplanted from other parts of the patient's body. CABG is typically reserved for patients for whom PCI is not an option.

For many years, CABG was the only procedure available to repair occluded coronary arteries. PCI first was used in the 1980s. At the time known as balloon angioplasty or percutaneous transluminal coronary angioplasty (PTCA), PCI is a minimally invasive procedure where physicians slip a balloon tipped catheter into the affected artery and inflate the balloon to re-open the passage and restore blood flow to the heart. In 1993, CABG and PCI were used at approximately the same rate among Medicare beneficiaries[7]. One of the early limitations to getting PCI (over CABG) was restenosis: a re-narrowing of the diseased vessel. In 1994, the FDA approved the Palmaz-Schatz stent by Johnson & Johnson for use in coronary arteries. Stents are wire-mesh cylinders developed to prevent the artery from closing. After balloon angioplasty, physicians would leave a stent in the diseased vessel to prop it open and prevent restenosis.

[7] According to the Dartmouth Atlas of Cardiac Surgery Report (2005), CABG and PCI were both used at annual rates of approximately 5 per 1,000 Medicare beneficiaries in 1992.

Throughout the 1990s and early 2000s, medical device firms continued to improve stents. A heparin coating was added in 2000, which lowered bleeding around the stent. This was followed by the Cypher drug-eluting stent in 2003 and the Taxus drug-eluting stent in 2004, which further improved the ability of stents to prevent restenosis and thrombosis (i.e., bleeding complications). By 2003, PCI was being used at over double the rate of CABG in the Medicare population[8]. Patients that would have received CABG in the past were now opting for PCI, and many patients that previously managed their conditions medically were now opting for a PCI.

Most PCIs are delivered directly after a coronary angiogram, which is a diagnostic procedure that locates the occluded sections of a patient's coronary arteries. Complications from PCI are rare but include stroke, sudden MI, vascular access complications, damaged kidneys (from contrast agents), vascular perforations, tamponade, and excessive bleeding. Many of these complications can result in inpatient death, which occurs in 1-2% of patients.

In addition to the interventional cardiologist, an interdisciplinary team works together to deliver each PCI. In general the physician is joined by a supervising nurse who is responsible for the patient holding areas and monitoring the safety of the patient, and a radiological technologist who is charge of the complex set of imaging and radiological equipment. However, PCI care teams can include secondary operators (i.e., other interventional cardiologists), cardiovascular trainees, and physician extenders, who each take on responsibilities when they are present. Most cath labs have support staff that includes a director responsible for the overall quality and administration of the lab, a

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[8] In 2003, Medicare was being used at a rate of 11.3 per 1,000 beneficiaries, while CABG was being used at a rate of 5.2 per 1,000 beneficiaries (Dartmouth Atlas of Cardiac Surgery, 2005).

medical physicist who monitors the equipment and radiation exposure within the lab, and other administrative staff (e.g., case managers, schedulers, inventory managers) who keep the lab running efficiently (Bashore et al., 2012).

Between 2001 and 2006, the number of hospitals with PCI programs in the United States grew from 1,176 to 1,695, an increase of 44% (Concannon, Nelson, Goetz, & Griffith, 2012). The growth was due in part to the improvements in PCI technology and its effectiveness in treating CHD, but was also due to research showing that faster times-to-PCI significantly improved the survival of patients with emergent heart attacks (Aversano et al., 2002; Nallamothu, Bradley, & Krumholz, 2007; Shahian, Meyer, Yeh, Fifer, & Torchiana, 2012). PCIs delivered in these situations are known as primary PCI (Keeley & Hillis, 2007). The availability of PCI had been limited to hospitals with cardiac surgery programs to ensure CABG would be available to patients with complications. But as the evidence continued to build showing a benefit for primary PCI, more hospitals started offering PCI services.

However, evidence suggests that the expansion did not significantly improve the geographic access to PCI (Concannon, Nelson, Kent, & Griffith, 2013; Horwitz, Nichols, Nallamothu, Sasson, & Iwashyna, 2013; Langabeer et al., 2013). Rather, the growth in PCI hospitals largely occurred in areas that already had access to a PCI hospital, suggesting that hospitals were adding these programs to capture the profitable and growing market for PCI.

In 2003, the average Medicare admission for PCI cost over $12,000. Hospitals did an average of 280 PCI[9] from the FFS Medicare program in 2003, which means that the

[9] This is the average among the hospitals in 2003 from my analytical sample described in the methods section.

average sized PCI hospital was making $3.36 million from the FFS Medicare program alone. Adding in PCI from other payers[10] at the same payment rate (which is probably conservative), then an average sized PCI hospital did $8.5 million in PCI business in 2003. Interventional cardiologists are paid separately and in 2003 earned approximately $800 per PCI. In 2003, these physicians did an average of 53 PCI[11] from the FFS Medicare program, which means they likely did around 132 PCI over all payers that year. Therefore, in 2003 the average interventional cardiologist earned approximately $106,000 in revenue from their PCI patients.

[10] Assuming Medicare FFS is 40% of the market (McGrath, 2000).

[11] This is the average among interventional cardiologists in 2003 from my analytical sample described in the methods section.

Chapter 4: Data

I investigate the effects of multihospital practice by physicians on inpatient mortality by looking at interventional cardiologists delivering percutaneous coronary interventions (PCI) to the Medicare Fee-For-Service (FFS) population over the period 2001 through 2004. The following describes my data and study sample.

Data

The data come from the Medicare Standard Analytic Files (SAFs) from 2001 through 2004. These are the final action claims for beneficiaries enrolled in the Medicare Fee-For-Service (FFS) program. PCIs were identified using Current Procedural Terminology (CPT) codes for coronary angioplasty (a.k.a., PTCA, balloon angioplasty) and stent placement[12] in the Part B claim record for physician services, known as the Carrier SAF. Each PCI claim record provided the unique physician identifier (UPIN) of the interventional cardiologist that performed the PCI, their tax identifier (TAXNUM), and the ZIP code of their practice.

Full calendar year extracts of Carrier and institution claims (Outpatient & Inpatient SAF) were pulled for each beneficiary identified with a PCI. Demographic (e.g., age, gender, and race) and residential ZIP code variables for each beneficiary were added from the beneficiary summary files. Mortality dates were added from the Vital Status file (current through 2011).

I connected the identified PCIs from the physician claim file to their corresponding hospital claim using the patient's unique beneficiary identifier (BENE_ID) and the date of their PCI. The hospital SAFs (Outpatient & Inpatient) contained the

[12] CPT codes indicating a PCI was performed were the following: 92980, 92981, 92982, 92984.

unique provider number (PRVDR_NUM) given to hospitals billing the Medicare program. This identifier allowed me to distinguish hospital locations in the claim record, and combined with the physician UPIN, allowed me to identify the hospital for each PCI a physician delivered[13]. Only short term acute care hospitals (STACHs) were kept[14].

I incorporated a rich set of provider and geographic characteristics onto the Medicare claim records from a variety of sources. I connected the physicians identified in the Carrier SAF to the American Medical Association's (AMA) Masterfile using their UPINs. This allowed me to incorporate physician demographics (e.g. sex, age) and medical training profiles (e.g. medical school, year of graduation) onto the PCI claim records. Next, I connected the hospitals identified in the Outpatient and Inpatient SAFs to the American Hospital Association's (AHA) Annual Survey using PRVDR_NUM and year. The AHA data allowed me to incorporate hospital characteristics (e.g. ownership, control & teaching status, cardiac program statuses, bed & staff sizes) and hospital ZIP code onto the PCI claim records. I connected the 5-digit ZIP codes for beneficiary residences, physician offices, and hospitals to the U.S. Census Bureau's Tiger Shapefiles to identify the longitude and latitude coordinates for each ZIP's centroid. This allowed me to calculate the distance in miles between cardiologists, patients and hospital locations. Additionally, I linked the ZIP codes to the Dartmouth Atlas Hospital Referral Region (HRR) numbers, which group ZIP codes into contiguous regions based on historical referral patterns.

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[13] I was unable to find a unique physician-hospital match for approximately 1% of the PCIs identified in the Carrier claims. These PCI were removed from the analysis during this step.
[14] STACHs were identified using the last 4 digits of the hospital's PRVDR_NUM. STACHs last 4 digits had to be less than 880. This restriction eliminated 920 PCIs (very few) from the analysis.

I was unable to match all identification codes (UPIN, PRVDR_NUM, or ZIP) for approximately 5% of the PCI identified in the Carrier claims to the set of outside characteristic files (i.e., non-CMS), so I removed these records from the analysis. In addition, I identified a “primary” office ZIP for physicians with more than one office ZIP code (i.e., multi-office) in a given year. The primary office ZIP was the one from which the physician billed the plurality of their PCIs, with all others considered “secondary” office ZIPs. Approximately 3% of PCI were billed from “secondary” office ZIPs and I removed these PCI to ensure each physician had only one office location in a given year.

I also made several simplifying restrictions and removed PCIs for beneficiaries who were not in FFS Medicare for the entire calendar year (i.e., they were in a Medicare Advantage plan for part of the year) and under age 65, or beneficiaries suffering from End Stage Renal Disease. From these data, I drew a subsample to study the relation between multihospital practice and inpatient mortality. I identified hospital stays for which PCI was likely the main reason a patient was admitted. These included admissions where atherosclerosis or AMI was the principal diagnosis[15]. In addition, I identified only the 1st PCI delivered during a patient’s hospital stay to avoid studying procedures delivered due to complications from the initial procedure[16].

Finally, I limited the sample to PCI delivered in hospitals that did 10 or more PCI in the year. This removed procedures delivered in hospitals barely involved in the PCI market[17]. Appendix table A.4.1 presents how my study sample population changes with each of steps described above.

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[15] Approximately 9.3% of PCI were delivered to patients admitted under different diagnoses.

[16] 2.9% of PCI were subsequent procedures.

[17] This removed just 0.3% of PCIs from my sample, but eliminated roughly half of the hospitals in my sample. Before imposing this final restriction I had 2,404 hospitals in my sample, and after making it I had

Study Sample

Table 4.1 describes my study sample[18]. From 2001 through 2004 there were over 1 million PCI delivered to my study sample. The number of PCI delivered each year was expanding, increasing 27% from 2001 to 2004. There were 1,276 unique PCI hospitals[19] in the study sample, and 9,500 unique physicians who billed Medicare for PCI from 2,174 unique 5-digit ZIP code locations (a.k.a. physician office locations or markets). The number of hospitals and physicians active in the PCI market was also expanding: PCI hospitals expanded 16% over the study period, while the number of PCI physicians grew 7%.

Table 4.1. Prevalence of PCI, PCI Hospitals, Physician and Physician Markets, and Multihospital Practice, 2001-2004

Year	Total PCI	Total PCI Hospitals	Total Physician Markets	Total Physicians	% Multihospital
2001	230,434	1,072	1,789	7,235	34.2%
2002	235,574	1,102	1,760	7,304	34.1%
2003	269,352	1,181	1,793	7,669	35.4%
2004	291,870	1,240	1,822	7,764	36.7%
All Years	1,027,230	1,276	2,174	9,500	43.6%

Physicians that delivered PCI in more than 1 hospital in a given year were identified as multihospital physicians. The prevalence of multihospital practice in any given year was roughly 35%, and increased slightly (7%) over the study period. Over the entire 4 year period, 43.6% of the unique physicians in my study sample worked in more than 1 hospital in at least one study year. This percentage is larger than the yearly percentages, indicating that not all physicians that multihospital practice do so every year.

1,276 hospitals. However, this final count of hospitals more closely aligns with the literature on PCI hospitals over this period (Concannon et al., 2012; Langabeer et al., 2013).

[18] After making all of the data exclusions described in the Data and Methods section above.

[19] Hospitals with at least 10 PCI in a given study year.

In chapter 7 I describe the prevalence of the outcome measures I study in this dissertation, please see Table 7.3.A for details on the prevalence of patient injury and Table 7.6.A for details on the prevalence of patient mortality after PCI.

Chapter 5: Regional Variation in Multihospital Practice

A sizable literature documents regional variations in treatment decisions, health care utilization, provider quality, and patient outcomes across the United States (Skinner, 2011). While several studies have documented the prevalence of multihospital practice at the national level (Fisher et al., 2007; Miller, Welch, & Englert, 1994), little is known about whether the prevalence of multihospital practice differs across regions of the United States. In this chapter, I document the prevalence of multihospital practice by physicians delivering PCI to the Medicare FFS market across Hospital Referral Regions (HRR) and estimate the relation between the prevalence of multihospital practice in a region and the number of PCI physicians and PCI hospitals practicing within it.

Multihospital practice may be related to the supply of PCI physicians per capita in a region: if a region is dense (i.e., there are relatively more PCI physicians per capita), then physicians will be more likely to protect their “primary” practice location from competitors and solo-hospital practice. Likewise, if a region is less dense (i.e., there are relatively fewer physicians per capita), then physicians will face less competition within their primary hospital for procedures and will be less likely to lose volume if they decide to split their time between their primary hospital and other “secondary” hospitals.

The number of PCI hospitals in a region should also matter. Regions with only one hospital will have no secondary hospital opportunities available to physicians, thus physicians must solo-hospital practice unless they decide to also work in other regions. Physicians in regions with more PCI hospitals per capita will have more opportunities to multihospital practice, and simultaneously, they will face more pressure to do it as the region’s PCI volume will be divided across more hospitals.

It is likely the prevalence of multihospital practice is a function of both: the number of PCI physicians in combination with the number of PCI hospitals available in a market. The number of physicians per capita may only matter given the number of hospital options in a market: regions with fewer hospitals per capita will make the effects of having more PCI physicians per capita more pronounced. In other words, physicians will tend to work in only one hospital to protect turf when the number of physicians per PCI hospital is high. Otherwise, physicians will not feel as compelled to protect their primary hospital from competitors.

The remainder of this chapter describes the methods I use to profile the prevalence of multihospital practice across HRR and a summary of the results.

Methods

Using the Hospital Referral Region (HRRs) of physicians in my study sample, I find the prevalence of multihospital practices ($Prevalence_{rt}$) in HRR r in study year t by calculating the proportion of physicians located in HRR r that delivered PCI in more than one hospital in year t, which is

$$Prevalence_{rt} = \frac{Multihospital\ PCI\ Physicians_{rt}}{Total\ PCI\ Physicians_{rt}}.$$

Taking quartiles of $Prevalence_{rt}$, I document the following:

1. How often HRRs remain in just 1 $Prevalence_{rt}$ quartile (e.g., always “low” prevalence)
2. Geographic differences across $Prevalence_{rt}$ quartile, and
3. HRR characteristic differences across $Prevalence_{rt}$ quartile.

Next, I model the prevalence of multihospital practice in HRR r in year t using the number of PCI physicians and PCI hospitals per 10,000 Medicare enrollees in an HRR. This equation can be written as:

(Equation 5.1)

$$Prevalence_{rt} = \beta_0 + \beta_1 Enrollees_{rt} + \beta_2 PCI\ Phys\ per\ 10K_{rt} + \beta_3 PCI\ Hosps\ per\ 10K_{rt} + \alpha_r + u_{rt},$$

where $Prevalence_{rt}$ is the proportion of physicians in HRR r that delivered PCI in multiple hospitals in year t (ranging from 0 to 1), $Enrollees_{rt}$ is the number (in 10,000s) of Medicare enrollees in HRR r in year t, $PCI\ Phys\ per\ 10K_{rt}$ is the total number of PCI physicians per 10,000 Medicare enrollees located in HRR r in year t, $PCI\ Hosps\ per\ 10K_{rt}$ is the number of PCI hospitals (which are hospitals with 10≤ PCI a year) per 10,000 Medicare enrollees in HRR r in year t, and α_r are fixed effects for HRR that capture time invariant differences between regions that may influence $Prevalence_{rt}$. u_{rt} is an error term.

Results

Using my study sample (described above in chapter 4), I find that physicians delivering PCIs were located in 305 (out of 306) HRRs over the period 2001-2004[20]. Many HRRs had zero multihospital physicians, while other HRRs had only multihospital physicians—a prevalence level of 100%. Table 5.1 documents the distribution of HRRs across quartiles of unadjusted prevalence in each study year. The quartiles group HRRs

[20] There were 0 physicians located in the IN-Lafayette HRR over the entire study period, 2001-2004, and 0 physicians located in VA-Lynchburg in 2002. All other HRRs were represented in each year.

into “zero”, “low”, “mid” and “high” prevalence categories, where low regions ranged from having 1 to 28% of their physicians in multihospital practices, and high regions ranged from having 57 to 100% of physicians in multihospital practices.

Table 5.1 – Percent of HRRs in Each Unadjusted Multihospital Prevalence Quartile by Year

Year	HRR (No.)	Quartile 1 “Zero” (0% - 0%)	Quartile 2 “Low” (1% - 28%)	Quartile 3 “Mid” (29% - 56%)	Quartile 4 “High” (57% - 100%)
2001	305	26.9%	24.6%	24.6%	23.9%
2002	304	28.0%	23.4%	24.3%	24.3%
2003	305	24.3%	25.2%	25.2%	25.2%
2004	305	22.0%	25.9%	26.2%	25.9%
Overall	1,219	25.3%	24.8%	25.1%	24.9%
Unique HRRs (No.) Ever In Quartile	--	101	124	136	105
% of Unique HRRs Always in Quartile	--	76.5%	60.9%	56.3%	72.1%

The final two rows of Table 5.1 describe how often HRRs remain in just one prevalence quartile: the first shows the unique number of HRRs that ever were in a quartile, and the second shows the percent of those that always were in that quartile. For example, 101 (out of 305) HRRs were in quartile 1 at least once, and of those 76.5% were always in that quartile over the study period. Table 5.1 shows that most HRRs do no switch out of their quartile, indicating that the relative prevalence category (e.g., zero, low, mid or high) of multihospital practices is fairly stable over my study period.

In figures 5.1.A though 5.1.D I do not find a clear geographic pattern in the unadjusted prevalence of multihospital practices: low and high prevalence regions exist all over the United States. Examining HRRs in 2001 descriptively, Table 5.2 lists the top

5 HRRs in each prevalence category based on the size of the Medicare enrollee population. The largest HRRs in the zero prevalence quartile are considerably smaller than the low or mid prevalence categories (Harrisburg PA compared to Boston MA or Los Angeles CA), and somewhat smaller than the high prevalence HRRs (e.g., Phoenix AZ). The number of PCI hospitals also differs considerably across these top HRRs, where zero prevalence regions have 1 or 2 PCI hospitals and high prevalence regions have almost 10 or more sometimes.

Figure 5.1.A – Unadjusted Prevalence of Multihospital Practices (MHPs) across HRR in 2001

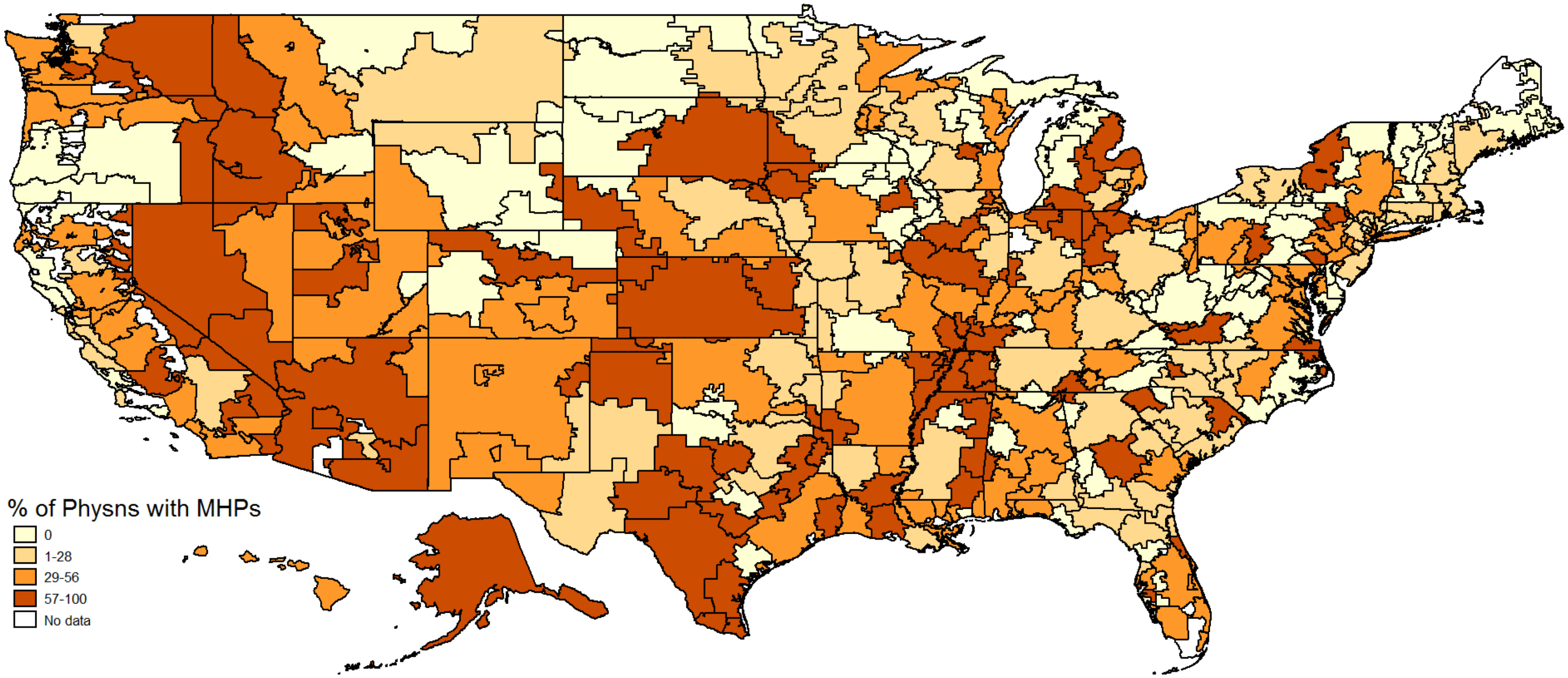


Figure 5.1.B – Unadjusted Prevalence of Multihospital Practices (MHPs) across HRR in 2002

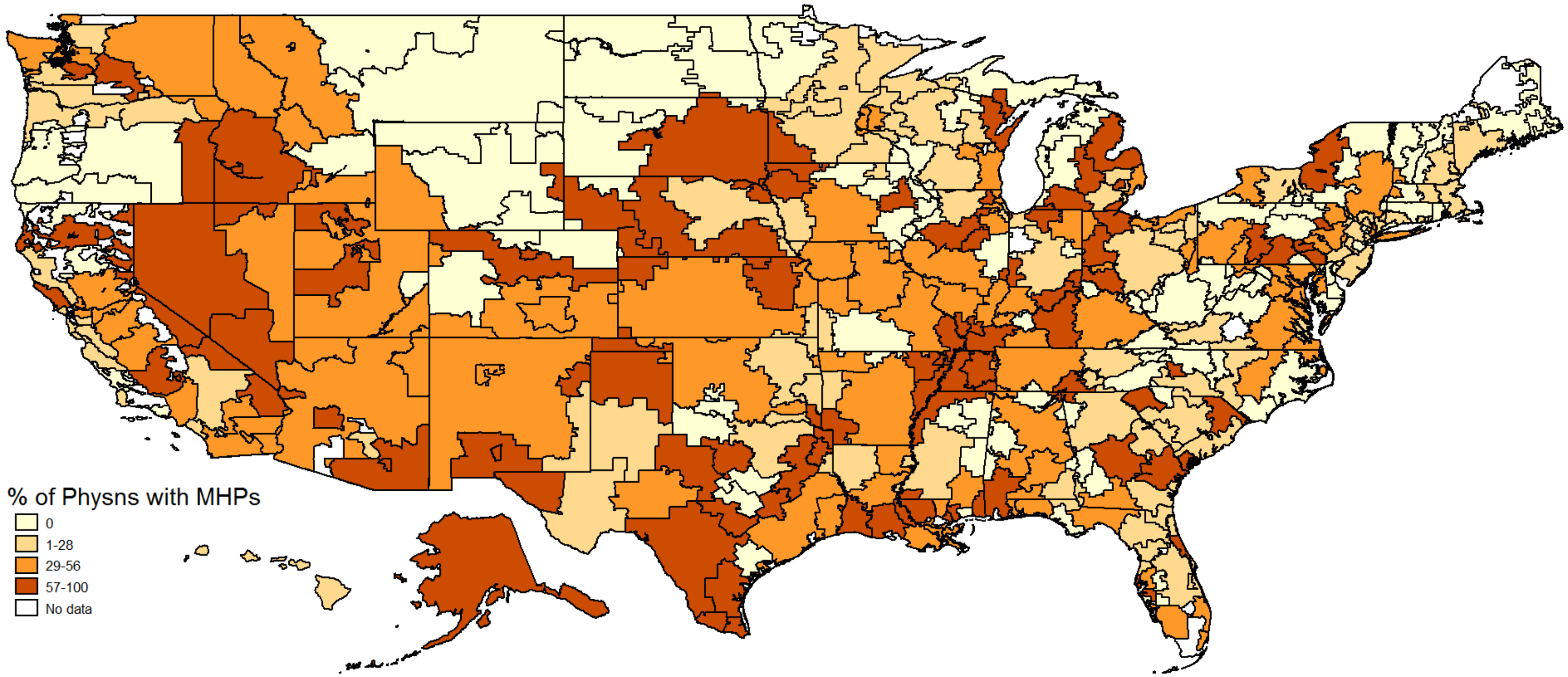


Figure 5.1.C – Unadjusted Prevalence of Multihospital Practices (MHPs) across HRR in 2003

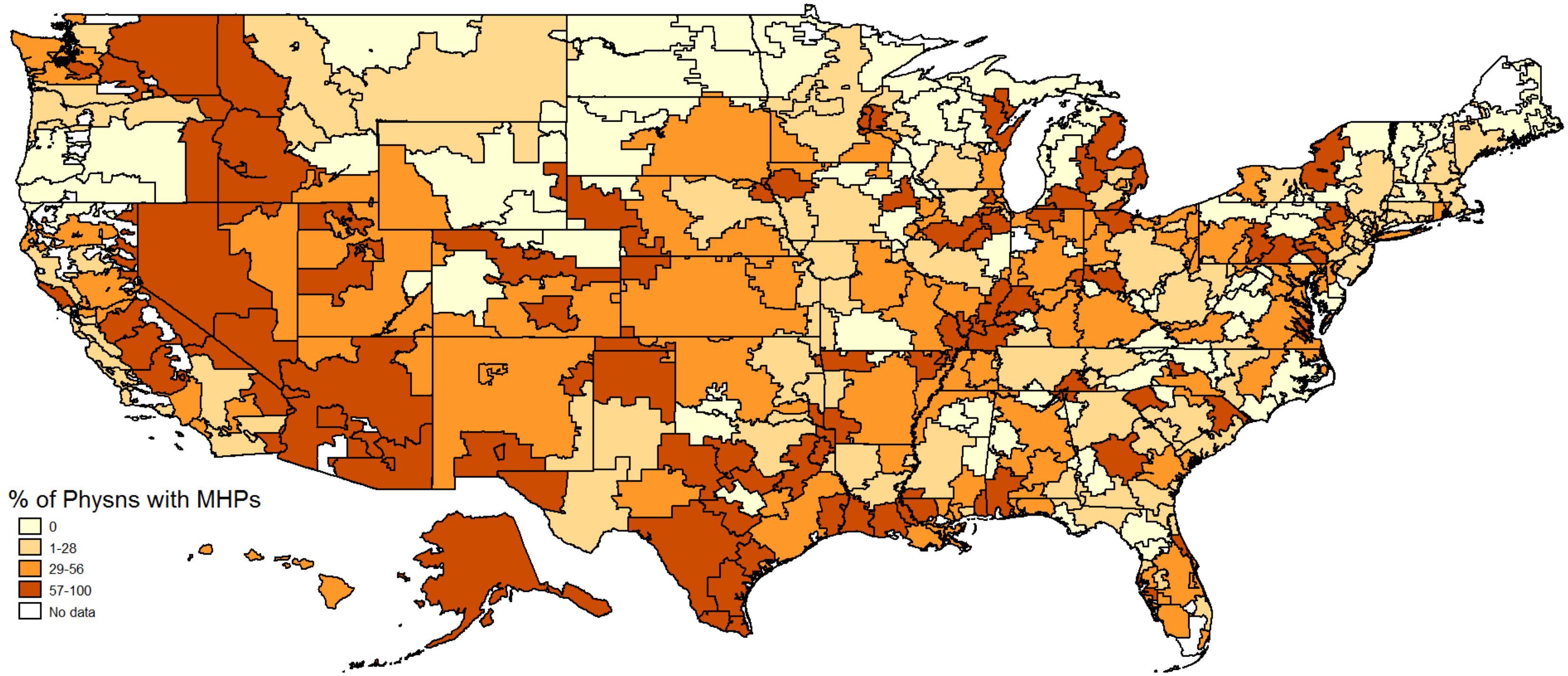


Figure 5.1.D – Unadjusted Prevalence of Multihospital Practices (MHPs) across HRR in 2004

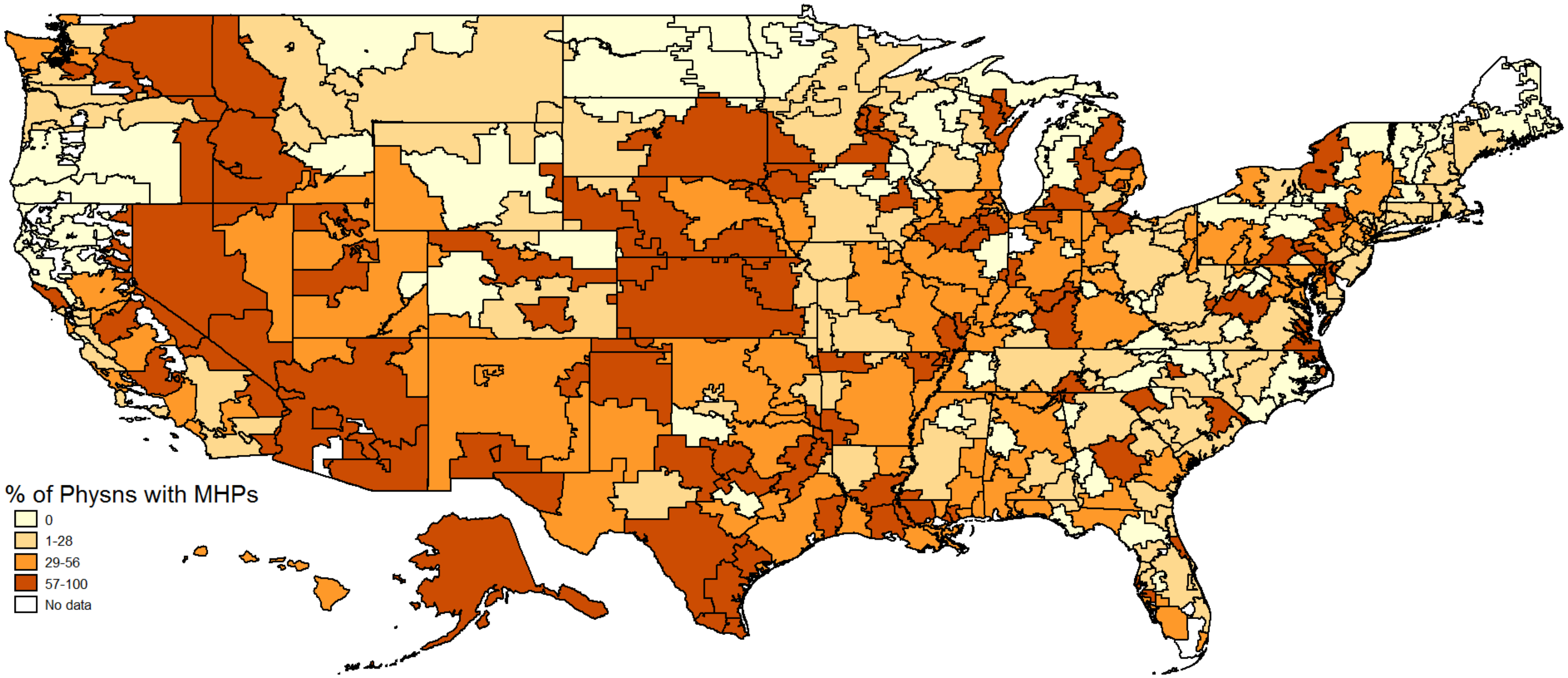


Table 5.2 – Top 5 HRRs in Each Unadjusted Prevalence Quartile Based on Medicare Enrollees, 2001

	Medicare Enrollees	PCI Hospitals	PCI Physicians	% Multihospital
Quartile 1 – Zero Prevalence (0% - 0% multihospital)				
PA-Harrisburg	134,876	2	23	0%
WV-Charleston	126,047	1	22	0%
MI-Grand Rapids	120,726	1	16	0%
MO-Springfield	115,865	4	24	0%
PA-Erie	111,951	2	11	0%
Quartile 2 – Low Prevalence (1% - 28% multihospital)				
MA-Boston	600,072	12	91	20.88%
NY-Manhattan	466,477	10	92	18.48%
GA-Atlanta	406,249	6	77	14.29%
NJ-Camden	382,813	3	35	20.00%
MN-Minneapolis	335,788	9	45	11.11%
Quartile 3 – Mid Prevalence (29% - 56% multihospital)				
CA-Los Angeles	817,737	36	232	36.64%
NY-East Long Island	544,309	8	65	29.23%
PA-Philadelphia	527,915	20	112	34.82%
PA-Pittsburgh	504,511	13	124	38.71%
FL-Orlando	436,659	8	93	29.03%
Quartile 4 – High Prevalence (57% - 100% multihospital)				
AZ-Phoenix	273,244	15	77	62.34%
TX-San Antonio	235,063	8	52	63.46%
CO-Denver	217,611	9	48	56.25%
TN-Memphis	180,399	6	47	59.57%
KS-Wichita	173,360	6	36	63.89%

Table 5.3 describes the average characteristics of HRRs in each quartile and overall. HRRs with relatively more multihospital practices are more populated on average. In addition, they have considerably more PCI physicians and PCI hospitals than regions with lower prevalence levels and smaller populations. Quartile differences in the number of physicians and hospitals per capita (per 10,000 Medicare enrollees) are not as stark, though. However, it's clear that regions with high multihospital prevalence do have (on average) more PCI hospitals per capita and fewer PCI physicians per hospital than zero, low or mid prevalence regions.

Table 5.3 – Average Characteristics of HRRs in 2001

Characteristics	Overall	Quartile 1 "Zero" (0% - 0%)	Quartile 2 "Low" (1% - 28%)	Quartile 3 "Mid" (29% - 56%)	Quartile 4 "High" (57% - 100%)
HRRs (No.)	305	82	75	75	73
Prevalence of MH Practices	0.315	0	0.160	0.406	0.736
	(0.288)	(0)	(0.0721)	(0.0792)	(0.111)
Residents (in 10,000s)	93.20	36.73	122.8	151.2	66.66
	(104.3)	(21.42)	(108.7)	(145.0)	(53.91)
Medicare Enrollees (in 10,000s)	10.81	4.979	13.70	17.36	7.661
	(10.78)	(2.945)	(10.86)	(14.92)	(5.352)
PCI Physicians					
Total	23.72	8.720	28.60	40.88	17.93
	(26.22)	(5.155)	(21.64)	(39.20)	(13.76)
Total per 10k Enrollees	2.279	1.905	2.283	2.526	2.441
	(1.034)	(0.808)	(1.065)	(1.207)	(0.930)
PCI Hospitals (≥10 PCI / year)					
Total	3.515	1.293	3.760	5.947	3.260
	(3.774)	(0.555)	(3.365)	(5.526)	(2.205)
Total per 10k Enrollees	0.378	0.316	0.300	0.403	0.501
	(0.204)	(0.137)	(0.156)	(0.225)	(0.224)
PCI Physicians per PCI Hospital	7.251	7.093	9.327	7.142	5.407
	(4.613)	(4.250)	(6.701)	(3.319)	(2.015)

Estimating equation 5.1, I find that the prevalence of multihospital practices is significantly related to the number of PCI hospitals per 10,000 Medicare enrollees in an HRR. The estimates from this model are shown in Table 5.4: first as a simple OLS regression without HRR fixed effects, then with HRR fixed effects. Then, the predicted prevalence at the 25th, 50th and 75th percentiles of PCI hospitals per capita and physicians per hospital are shown in Figures 5.2.A and 5.2.B. These predictions are based on the fixed effects model coefficients in Table 5.4.

Table 5.4 – Relation between HRR Prevalence of Multihospital Practices and the Number of PCI Physicians and PCI Hospitals per 10,000 Medicare Enrollees, 2001-2004

	OLS Regression		Add HRR Fixed Effects	
VARIABLES	Coef.	SE	Coef.	SE
Medicare Enrollees (in 10,000s)	0.00337**	(0.00104)	0.00941	(0.0107)
PCI Physicians per 10k Enrollees	-0.0106	(0.0170)	-0.00824	(0.0288)
PCI Hospitals per 10k Enrollees	0.603***	(0.0933)	0.704***	(0.157)
PCI Physicians per PCI Hospital	-0.00240	(0.00309)	-0.0132*	(0.00598)
Constant	0.0968	(0.0501)	0.0600	(0.124)
Observations	1,219		1,219	
R-squared	0.181		0.258	
Number of Fixed Effects	--		305	
SD of Overall Error Residuals			0.106	
SD of Fixed Effect Residuals			0.260	
Rho (Intraclass Correlation)			0.857	

Standard errors are clustered at the HRR level
*** p<0.001, ** p<0.01, * p<0.05

In figure 5.2.A, going from 25th to 75th percentile of PCI hospitals per enrollees increases an HRR's predicted prevalence of multihospital practice from 22.6% of physicians to 40.0%. In other words, if a region doubled the number of PCI hospitals per 10,000 enrollees (from .247 to .494), we would see a 77% increase in the prevalence of multihospital practices. While the number of PCI physicians per capita does not appear to directly influence prevalence levels, it does hold a partial effect with prevalence when combined with the number of PCI hospitals in an HRR. Regions with more physicians per hospital have fewer multihospital practices. As shown in Figure 5.2.B, going from the 25^{th} to 75^{th} percentile of physicians per hospital (or 4.5 to 8 physicians per hospital) reduces the prevalence of multihospital practices by 13%. And while multihospital practice appears to be more prevalent in more populated HRRs (i.e., regions with more Medicare enrollees)—which can be seen in the OLS regression output of Table 5.3—regional population size does not appear to matter after including HRR fixed effects, suggesting it is not associated with prevalence levels.

Together, the 4 variables I include in equation 5.1 explain 25% of the within HRR variation in multihospital practice. While this is considerable, most of the within region variation in multihospital prevalence is left unexplained. It is likely that other regional differences could explain more: the Rho value in Table 5.3 (a.k.a. the intraclass correlation) is 0.856 indicating 85.6% of the variation multihospital prevalence is due to differences between regions.

Figure 5.2.A – Predicted Prevalence of Multihospital Practice in an HRR at the 25th, 50th, and 75th Percentile of PCI Hospitals per 10,000 Medicare Enrollees, 2001-2004

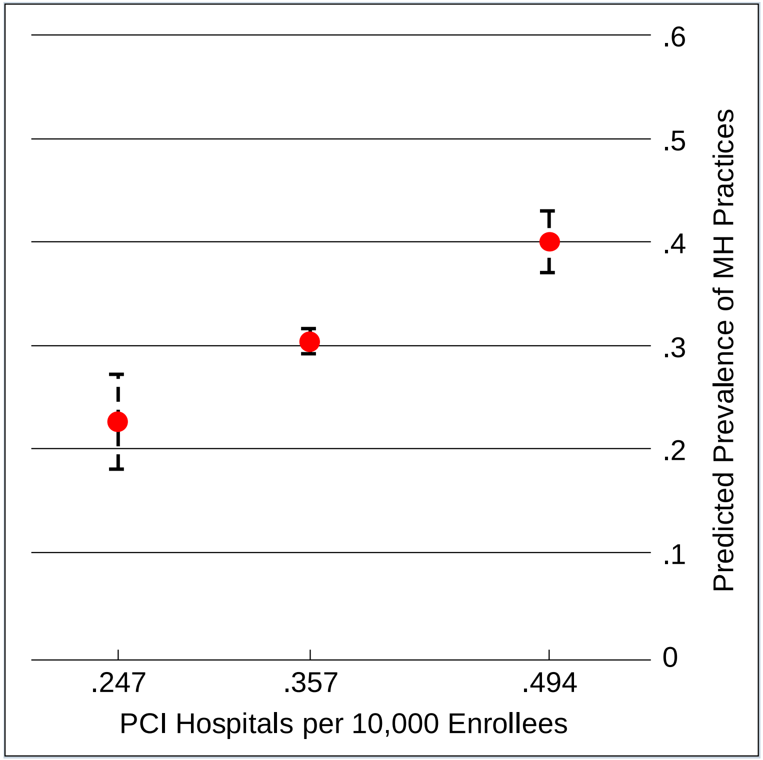
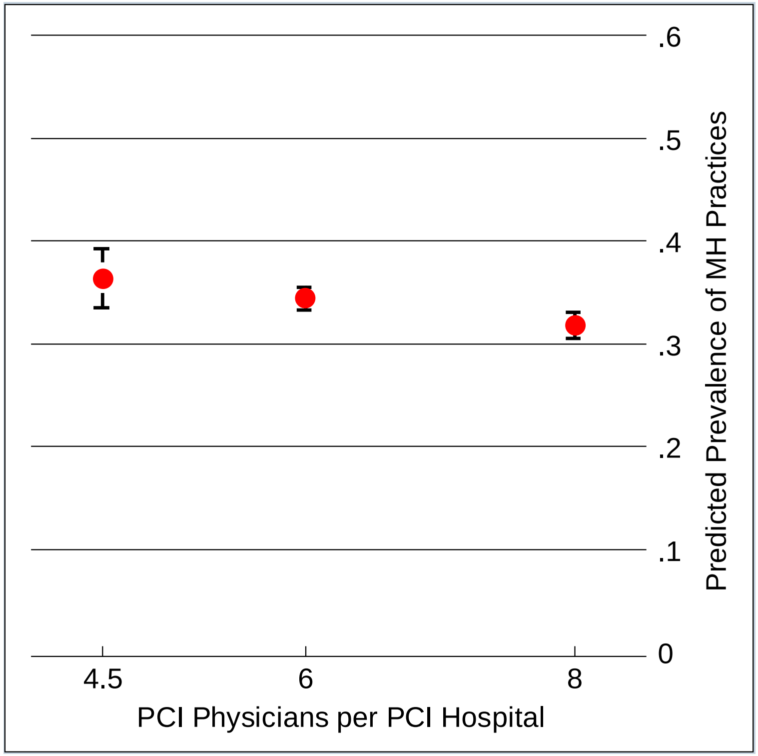


Figure 5.2.B – Predicted Prevalence of Multihospital Practice in an HRR at the 25th, 50th, and 75th Percentile of PCI Physicians per PCI Hospital, 2001-2004



Chapter 6: Development of an Exogenous Measure of Multihospital Practice

In this chapter, I focus on the physician's decision to deliver procedures in more than 1 hospital[21]. Conceptually, physicians seek more procedure volume for both income and quality reasons and one way to get it is by working in multiple hospitals. Their decision to do so is constrained by the higher cost of practicing across multiple hospitals, which is a function of the spatial proximity of hospitals in their local market. A consequence of multihospital practice is that multihospital physicians work with more hospital teams than solo-hospital physicians. This reduces the shared experience between physicians and hospitals, limits the availability of the physician before and after procedures, and can potentially reduce the mutual investments physicians and hospitals make to improve the quality of their services. These factors could increase the risk of medical errors being made during a patient's hospital stay and contribute in other ways to worse patient outcomes such as inpatient death.

Multihospital practice may expose their patients to higher risk for an adverse outcome like inpatient mortality; however, observing this influence empirically can be obscured by unmeasured quality differences between physicians and hospitals and unmeasured patient severity. These factors influence patient outcomes, but they also could influence multihospital practice. Figure 6.1.A presents my conceptual model. In this chapter, I develop predicted measures of multihospital practice that are free from confounding by using a set of instruments that identify multihospital practice by physicians but do not directly influence their patient's outcomes (which are covered in the next chapter). The goal is to create an "instrumented" or "corrected" measure of multihospital practice that is unrelated to unobserved factors that also influence patient

[21] My conceptual framework benefited from conversations with interventional cardiologist faculty in the Department of Medicine Cardiovascular Division at the University of Minnesota in the Fall of 2015.

outcomes. Figure 6.1.B depicts the role of instrumented multihospital practice in my conceptual model. The remainder of this chapter proceeds as follows: I describe (1) why it is necessary to instrument for observed measures of multihospital practice, (2) my conceptual framework on the physician's decision to practice in multiple hospitals, (3) my empirical approach to predict the probability of multihospital practice, and (4) the results.

Unobserved Factors in the Relationship between Multihospital Practice and Adverse Patient Outcomes

While multihospital practice is believed to create less-experienced physician-hospital teams and more opportunity for medical errors to be made during a patient's hospital stay, its influence is difficult to observe empirically due to other factors. Namely, there could be favorable selection into multihospital practices if physicians that choose to practice in multiple hospitals are more skilled than their solo-hospital counterparts. This scenario could be the case if more hospital opportunities exist for physicians with better reputations. If higher quality physicians are more likely to work in multiple hospitals, then its detrimental effects will be obscured (i.e., biased downward, understated) when comparing their performance to solo-hospital physicians. In the opposite case, if the less skilled or experienced physicians need to supplement their procedure volume by working in multiple hospitals, then multihospital physicians might be lower quality than physicians who attract enough volume in just 1 hospital. In this case, estimates of the relationship between multihospital practice and adverse patient outcomes like inpatient mortality will be biased upward (i.e., overstated).

Figure 6.1.A – Observed (or "Uncorrected") Measure of Multihospital Practice

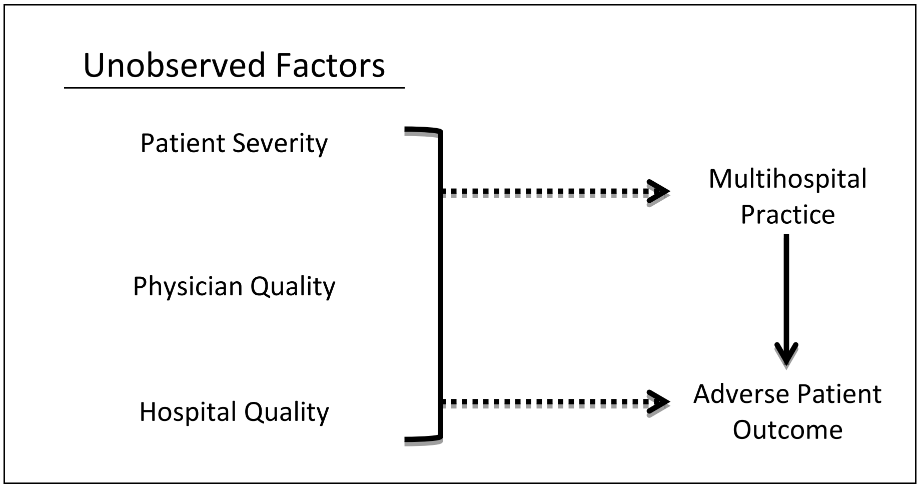
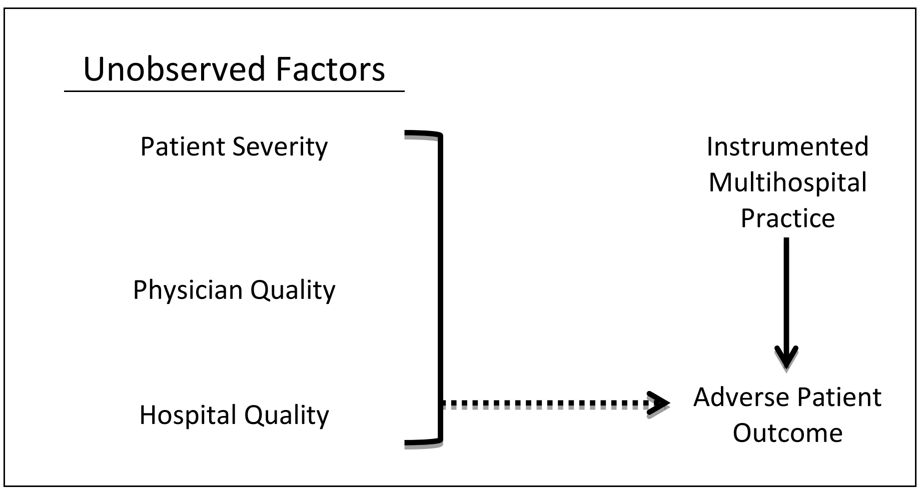


Figure 6.1.B – Instrumented (or "Corrected") Measure of Multihospital Practice



Some evidence suggests that multihospital physicians do more volume than solo-hospital physicians (Huckman & Pisano, 2006), indicating they draw more patients overall and might have better reputations for delivering procedures. Yet, little is known about what causes physicians to work in multiple hospitals, making it hard to say in what direction unobserved physician quality biases estimates of the relation between multihospital practice and adverse patient outcomes.

Similarly, unobserved quality differences exist between hospitals: if multihospital practices tend to occur over hospitals that are higher (or lower) quality, then the estimated relation with adverse outcomes will be understated (or overstated).

The effect of multihospital practice on patients' outcome also can be obscured by sicker (or healthier) patients systematically selecting these physicians. For example, some multihospital physicians are on-call to deliver emergency procedures in their non-primary hospitals. Emergent patients suffer from more acute conditions than elective patients and they are more likely to have worse outcomes due to their severe and time-sensitive conditions. If patient severity is not fully accounted for, and multihospital physicians attract more severe patients, then the risk from multihospital practice will be overstated. The opposite could be true if multihospital physicians serve healthier patients (i.e., with fewer comorbidities): attracting relatively healthier patients will bias the effect of multihospital practice on adverse outcomes downward if patient severity is not fully controlled.

One way to estimate the unbiased effect of multihospital practice on patient outcomes would be to randomize physicians to multi or solo-hospital practices, randomize hospitals to these physicians, and randomize patients to physician-hospital teams. This approach works because it alters the value of multihospital practice using variation not directly related to patient outcomes (it's random after all). In lieu of this prospective approach, my study uses secondary data and I employ a two-stage modeling approach to conduct the "randomization". In the first stage, I predict the probability of multihospital practice using instruments that are not directly related to patient outcomes. This creates an altered measure of multihospital practice that is based on variation not directly related to a patient's outcome. In the second stage, I model patient outcomes using my predicted measure to estimate the unbiased relation between multihospital practice and adverse patient outcomes following PCI.

The key to this approach is employing a set of instruments that predict multihospital practice but do not directly influence patient outcomes. To motivate the instruments I use, the next section presents a conceptual framework on why physicians decide to practice in multiple hospitals.

The Physician's Decision to Practice in Multiple Hospitals

Multihospital practice is driven by the physician's desire for more procedure volume. Physicians face strong incentives to achieve higher volumes. Under quantity based payment systems, higher volume translates directly into more income. In addition, volume is widely seen as a measure of competency, signaling greater experience and quality to prospective payers, patients, and referring physicians. Advocacy organizations like the Leapfrog group place addition pressure on providers by making recommendations to their members (i.e., payers) to contract with providers that meet minimum volume thresholds (Khuri & Henderson, 2005), and trade organizations like the American College of Cardiology and the American Heart Association make volume recommendations for providers as one of the few criteria for hospital and physician competency (Smith et al., 2001), placing more pressure on physicians in some specialties to stay above volume minimums.

One way physicians can increase procedure volume is through multihospital practice. In markets with more than 1 hospital, the population of patients seeking a procedure will be divided across hospitals for a variety of reasons: selective contracting from health plans, geographic proximities of hospitals, and entrenched referral patterns among primary care physicians. Multihospital practice allows physicians to overcome divided patient groups by making themselves available in more hospitals. Conditional on their market, physicians that practice in multiple hospitals have access to more patients than solo-hospital physicians.

The physician's decision to have a multihospital practice is constrained by the higher cost of working across multiple hospitals. Compared to solo-hospital practice, multihospital practice is necessarily less efficient: it requires physicians to familiarize themselves with staff from more than 1 hospital, different hospital equipment, and more than 1 process of care. The more hospitals a physician works in, the more time they need to learn how to deliver procedures in each location. This raises the cost of delivering procedures and can dissuade physicians from multihospital practice if they decide it's simply too burdensome.

Some multihospital physicians face higher costs than others. Beyond learning, the additional cost from multihospital practice depends on the spatial configuration of hospitals in a physician's market. When hospitals are located farther apart in a market, multihospital physicians will spend more time travelling between them. This increases the cost of delivering procedures through higher travel expenses, but more importantly, farther distances raise the physician's opportunity cost by taking up more of the time they have available to deliver services to patients—reducing their earning potential. Therefore, physicians that practice in markets where hospitals are farther apart will face higher costs from working in more than 1 hospital and will be less likely to do it.

Practically speaking, multihospital practice occurs in 2 ways. First, physicians can hold credentials in more than 1 hospital and work in each whenever they want. These physicians use their hospitals according to their own discretion and the availability of the hospital. Alternatively, physicians can enter into service contracts (a.k.a., professional service agreements) with hospitals to provide services to the hospital's patients on certain days. In return, the hospital compensates the physician with a negotiated payment. Common service contracts take the form of being on-call at a hospital to offer emergency procedures or offering elective procedures at a hospital on specific days. Hospitals that offer these contracts tend to be smaller (i.e., lower procedure volumes) and are unable to staff their service offerings with full-time physicians. Markets that have small PCI hospitals will be more likely to have contract opportunities and physicians located in these markets will be more likely to work in more than 1 hospital with these contracts.

Estimating the Probability of Multihospital Practice ($\widehat{MH}_{jt}$)

The probability that physician j decides to multihospital practice in period t can be written as:

(Eq. 6.1) $Prob(MH_{jt} = 1) = \delta_1 Z_{jt} + \alpha_j + \varepsilon_{jt},$

where Z_{jt} are instrumental variables that influence the decision to practice in more than 1 hospital (but are not related to patient outcomes), α_j is a fixed effect for the physician, and ε_{jt} is an error term.

In what follows, I distinguish "large PCI hospitals" with at least 40 PCIs in a year and "small PCI hospitals" with 10 to 39 PCI in a year. 40 PCI during a given year represents sufficient volume to be a full-time hospital for a physician. Because I use the Medicare FFS population only, which is believed to be roughly 40% of the PCI market, 40 PCI per year translates to a hospital that likely did 100 PCI that year overall. Small and large PCI hospitals together are "PCI hospitals."

I use four Z_{jt} variables to capture differences in the presence and proximity of PCI hospitals within physician j's market. First, I include the average of the bilateral distances between each pair of large PCI hospitals (≥40 PCI) in the market. Second, I include an indicator for whether the physician's market has at least 1 PCI hospital. Third, I include a categorical variable for the number of small PCI hospitals (<40 PCI per year) in the physician's market—hospitals where PCI is delivered infrequently—divided into 3 categories: 0 small hospitals, 1 or 2 small hospitals, and 3 or more small hospitals. And fourth, I include a categorical variable for the number of large PCI hospitals (those with ≥40 PCI) in the physician's market, split into the following 5 categories: 0 large PCI hospitals, 1, 2-4, 5-9, and 10 or more large PCI hospitals.

I define a physician's market as the set of zip codes within 25 miles of their office zip code[22], where 25 miles (approximately 30 minutes) is probably the farthest a

[22] I create physician markets using the centroids (approximate center) of 5 digit zip codes that fall within 25 miles of a physician's office zip. First, I spatially locate each centroid using geocoded longitude and

physician would want to be from a patient who needs an emergency PCI. Each market can be characterized by the hospitals and patients that are located within it and more than one physician will have the same market area if their offices are located in the same 5-digit zip code.

Figure 6.2 shows two hypothetical physician markets: market A and market B. Using numbers, Figure 6.2 depicts the spatial location of large PCI hospitals in each market. To create the average bilateral distance between PCI hospitals, I find the distance between each large PCI hospital pair in a physician's market and take the average of the set. For example, in Figure 6.2 the bilateral distance between hospital 1 and hospital 2 in market A is 5.49 miles, with the remaining bilateral distances for market A shown in the lower left triangle of A's hospital-to-hospital distance matrix. Taking the average of the set I find that the average bilateral distance in Market A is small (5.44 miles). This is because hospitals are clustered around each other in the market space. In market B, the average bilateral distance is much larger (24.56 miles) because the hospitals are dispersed across the market space.

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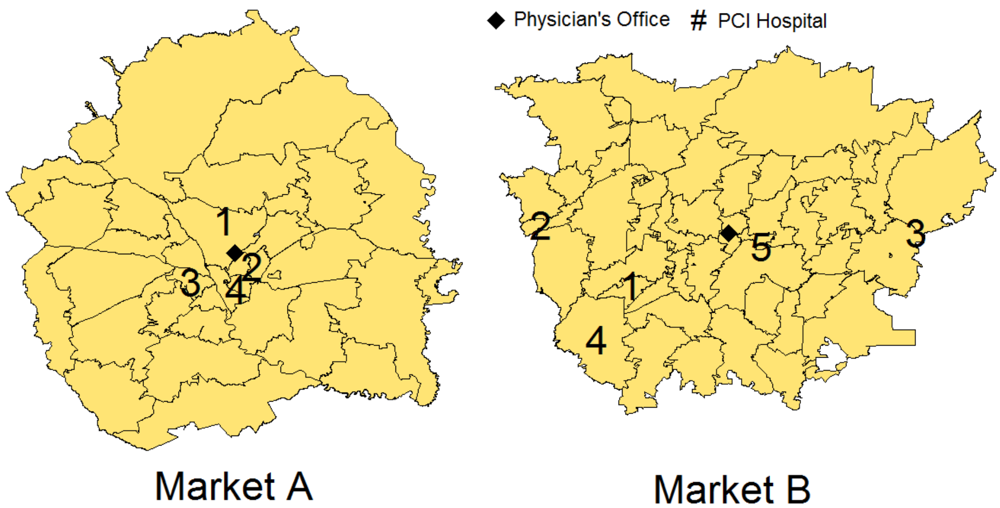
latitude coordinates. Next, I calculate the distance in miles between the center and each surrounding centroid and include those within 25 miles of physician's office zip.

Figure 6.2 – Calculating Average Bilateral Distances between Hospitals in a Physician's Market



Market A – Matrix of Hospital-to-Hospital Distances (miles)

	Hospital 1	Hospital 2	Hospital 3	Hospital 4
Hospital 1	—			
Hospital 2	5.49	—		
Hospital 3	7.85	5.86	—	
Hospital 4	7.04	2.55	3.87	—
Average Bilateral Distance between Hospitals in Market A:				5.44

Market B – Matrix of Hospital-to-Hospital Distances (miles)

	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5
Hospital 1	—				
Hospital 2	14.59	—			
Hospital 3	34.65	44.79	—		
Hospital 4	7.74	18.29	39.92	—	
Hospital 5	17.13	26.65	18.21	23.61	—
Average Bilateral Distance between Hospitals in Market B:				24.56	

Physicians with market B (i.e., those located at the black diamond) will be less likely to multihospital practice (compared to market A) because of the higher cost of travelling between hospitals. However, if the average distance in market B fell due to PCI programs entering or exiting, then the inconvenience of multihospital practice in market B would also fall and physicians with this market would become more likely to multihospital practice. The change in average distance is not necessarily prescribed by whether a market adds or loses a large PCI hospital: average bilateral distance can go up or down under entry or exit depending on where existing large PCI hospitals and the entrant are located. For example, average distance will increase if an entrant locates near the outer boundary of Market A. Average distance will fall if hospital 3 exits Market B.

In addition to the average bilateral distance measure, I include 3 more instrumental variables in Z_{jt}. To distinguish between physician markets that do not have any PCI hospitals (small or large) and markets that do, I include an indicator for at least 1 PCI hospital. Markets without a PCI hospital can still have PCI physicians that travel farther than 25 miles to the PCI hospitals they work in. Moreover, physicians in these markets can be multihospital or solo-hospital physicians. However, in these markets the average bilateral distance measure is set to 0 so it is important to include this indicator to distinguish these markets from those with 1 large PCI hospital, or more than 1 large PCI hospital in the same zip code—markets that also have average bilateral distances of 0[23].

Next, small PCI hospitals (10 to 39 PCI a year) that don't have enough volume for a full-time physician will likely offer professional service agreements to physicians to provide part-time PCI services. To account for the availability of part-time work in physician markets, I include a categorical variable for the number of small PCI hospitals (<40 PCI per year) in the physician's market. Markets that have more small PCI hospitals will have more part-time work opportunities and the probability a physician will multihospital practice will be higher.

Finally, I include a categorical variable for the number of large PCI hospitals (those with ≥40 PCI) in the physician's market. Just like with small PCI hospitals,

[23] I distinguish markets with 1 large PCI hospital and markets with more than 1 large PCI hospital in the same zip code by including the categorical variable for the number of large PCI hospitals in the physician's market.

physician's located in markets with more large PCI hospitals will have a higher probability of working in more than 1. However, including this variable accounts for two additional factors. First, markets with only 1 large PCI hospital are quite different from other markets, including markets with 0 large PCI hospitals. When there is only 1 hospital large enough to sustain a full-time PCI physician, physicians may be discouraged from multihospital practice by the hospital or by the threat of losing their place to another physician. Therefore, physicians in markets with 1 large PCI hospital will have a lower multihospital probability compared to markets with more than 1 large PCI hospital and markets without a large PCI hospital. Second, by having a category for 1 large PCI category, I am able to distinguish 0 average bilateral distances by virtue of just having 1 large hospital from markets with 0 distances by virtue of having more than 1 large hospital in the same zip code.

I use a linear probability model with physician fixed effects to estimate Eq. 6.1 and I cluster the standard errors at the physician level[24]. To gauge the ability of the instruments to predict multihospital practice (i.e., testing for weak instruments), I use an F-test of Z_{jt}. In general, F-test values greater than 10 indicate that the instruments are not weak.

Using the estimated coefficients on the instrumental variables (which are based on within physician variation only), I predict the probability each physician j is multihospital during period t ($\widehat{MH}_{jt}$). This includes making predictions for physicians that (in reality) were always multihospital or always solo-hospital over the study period. As I will describe in chapter 7, I include indicators for each quartile of $\widehat{MH}_{jt}$ in my

[24] Because some physicians change markets over 2001-2004, physicians do not nest completely within a market and I cannot cluster the errors at the market level.

patient outcome models and test whether a higher probability of multihospital practice (e.g., quartile 4 compared to quartile 1) is associated with adverse patient outcomes following PCI.

Results

The analysis in this chapter is at the physician-year level. Table 6.1 presents the average characteristics of physician-years overall, and by multihospital status: either "yes", the physician worked in multiple hospitals that year, or "no", the physician didn't. Of the 29,972 physician-years in the study sample, 35% were multihospital physician-years. Multihospital physicians worked in 2.3 PCI hospitals on average, were more likely to be foreign trained, and they had roughly ½ fewer years of experience since graduating from medical school. Compared to solo-hospital physicians, multihospital physician PCI volume was 34.7% higher each year: solo-hospital physicians did 30.54 PCI per year (on average), while multihospital physicians did 41.15. The extra-volume was due to the PCI volume they deliver in other PCI hospitals—on average, they deliver approximately the same amount of volume in their patient's hospital as solo-hospital physician (maybe slightly less, but insignificantly so).

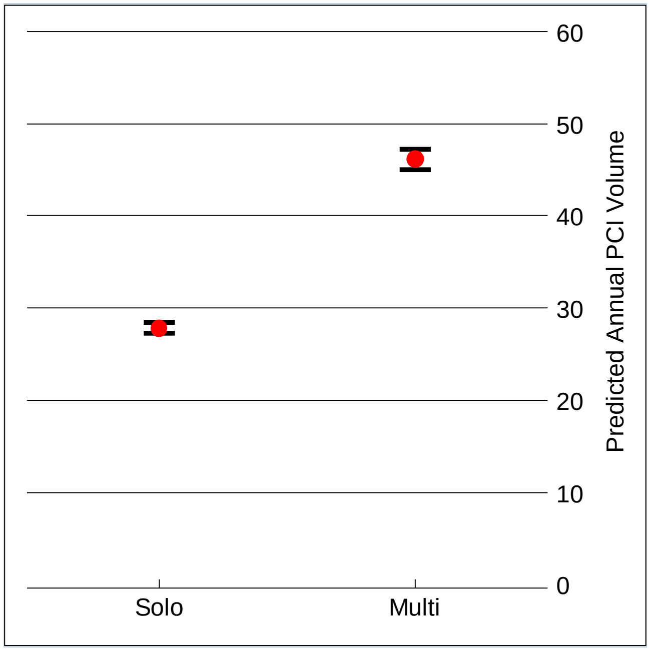
Table 6.1 – Average Physician-Year Characteristics by Multihospital Status, 2001-2004

Characteristics	Overall	Multihospital Physician in Year? Yes	No	p
Unique Physician-Years, No.	29,972	10,536	19,436	--
PCI Hospitals Worked In	1.45	2.30	1	< .001
Annual PCI Volume	34.27	41.15	30.54	< .001
Years Since MD	21.49	21.22	21.64	< .001
Medical School Training				
Top 29 MD School	19.55%	16.79%	21.05%	< .001
30+ Ranked MD School	49.44%	50.11%	49.08%	.09
Foreign Trained	30.99%	33.08%	29.85%	< .001

As I showed in chapter 5, multihospital practices were more prevalent in regions with larger Medicare populations. One possibility is that the average volume differences between multihospital and solo-hospital physicians reflects differences in patient demand between markets where it is more or less common to multihospital practice. In other words, multihospital practice may not actually hold a relation with higher volume levels. While showing this relation is not a goal of my dissertation, it holds important conclusion validity to the conceptual framework described above.

To explore this possibility more closely, I modeled annual physician PCI volume on an indicator for multihospital practice ($MH_{jt} = 1$) and a fixed effect for the physician's market, which removes differences between market's that are time-invariant. Figure 6.3 shows that after controlling for differences in physician markets, multihospital physicians actually do even more PCI volume each year compared to solo-hospital physicians. Predicted annual volume for multihospital physicians is 46.15 PCI per year, approximately 18.3 more (95% CI, 16.62 to 19.99) or 72% higher than solo-hospital physicians who are predicted to deliver only 27.84 PCI per year. Assuming that FFS Medicare (my study sample) is approximately 40% of the physician's entire PCI practice (McGrath, 2000), then the full practice difference was more like 45.75 additional PCI per year. The average Medicare allowed charge for a PCI over my study's period (2001 through 2004) was $820, which means that the average financial gain from multihospital practice would have been an additional $37,515 per year.

Figure 6.3 – Predicted Annual PCI Volume by Multihospital Status, 2001-2004 (conditional on market)



I can estimate the model for Figure 6.3 because there are typically more than 1 PCI physicians located in a given physician market (i.e., same zip code). Table 6.2 shows characteristics of physician markets over the full study period (all years) and in each study year. In 2001, for example, approximately 70% of PCI physicians share the same market with at least 1 additional PCI physician. Large PCI hospitals in physician markets are on average 9.83 miles from each other. This average bilateral distance is only slightly greater, by 0.16 miles, if small PCI hospitals are included in the measure. In 2001, there were 86 markets (4.81%) without PCI hospitals. Most markets had more than 1 large PCI hospital (82.78%), while a slight majority of markets were without small PCI hospitals (51.93%).

Table 6.2 – Characteristics of Physician Markets

Characteristics are shown as % of markets unless noted otherwise	All Years	2001	2002	2003	2004
Physician Markets, No.	7,164	1,789	1,760	1,793	1,822
PCI Physicians with Same Market					
1	28.99%	30.41%	29.32%	27.55%	28.70%
2-4	38.85%	38.90%	38.30%	39.93%	38.25%
5-9	23.17%	22.02%	23.07%	23.54%	24.04%
10+	8.99%	8.66%	9.32%	8.98%	9.00%
Average Bilateral Distance between					
PCI Hospitals, miles (sd)	10.44 (7.22)	9.99 (7.09)	10.30 (7.18)	10.67 (7.23)	10.80 (7.33)
Large PCI Hospitals only, miles (sd)	10.07 (7.37)	9.83 (7.29)	10.00 (7.37)	10.13 (7.35)	10.31 (7.46)
Number of PCI Hospitals					
0	4.17%	4.81%	4.49%	3.74%	3.68%
1	11.81%	11.12%	11.70%	11.77%	12.62%
2	12.65%	13.42%	12.67%	12.21%	12.29%
3-5	21.79%	21.74%	20.85%	22.53%	22.01%
6-10	20.85%	23.87%	21.36%	18.85%	19.37%
11+	28.73%	25.04%	28.92%	30.90%	30.02%
Number of Small PCI Hospitals (10 to 39 PCI/year)					
0	47.63%	51.93%	47.73%	43.50%	47.37%
1-2	35.27%	32.20%	34.72%	41.05%	33.15%
3+	17.10%	15.87%	17.56%	15.45%	19.48%
Number of Large PCI Hospitals (40 or more PCI/year)					
0	5.35%	5.98%	5.85%	4.85%	4.72%
1	12.44%	11.24%	12.44%	12.99%	13.06%
2-4	30.76%	31.81%	29.72%	30.34%	31.17%
5-9	27.53%	29.46%	27.44%	27.33%	25.91%
10+	23.93%	21.52%	24.55%	24.48%	25.14%

Using the average bilateral distance between large PCI hospitals, an indicator for markets with at least 1 PCI hospital, and the categories of large and small PCI hospital counts described above, I estimated Eq. 6.1. Table 6.3 shows the estimates from this model. Physicians in markets with greater distances between large PCI hospitals are less likely to work in multiple hospitals. Specifically, when large PCI hospitals are 1 mile closer, the probability (from 0 to 1) a physician will multihospital practice is 0.00476 higher (95% CI, 0.0019 to 0.0075). Expanding this result, Figure 6.4.A shows the probability of multihospital practice by average bilateral distance from 0 to 25 miles. When hospitals are 0 miles from each other, the probability of working in more than 1 is 0.398 (95% CI, 0.370 to 0.425), falling to 0.279 (95%, 0.236 to 0.321) when hospitals are 25 miles from each other.

Table 6.3 – Relation between the Physician's Decision to Work in Multiple Hospitals and Market Characteristics, 2001-2004

VARIABLES	Coef.	SE
Ave. Distance between Large PCI Hospitals	-0.00476***	(0.00144)
Market has at Least 1 PCI Hospital	0.0964	(0.0694)
Small PCI Hospitals (10 to 39 PCI/year)		
0 (ref)	--	--
1-2	0.0551***	(0.00967)
3+	0.0868***	(0.0131)
Large PCI Hospitals (40 or more PCI/year)		
0 (ref)	--	--
1	-0.164***	(0.0494)
2-4	0.0865	(0.0538)
5-9	0.150**	(0.0563)
10+	0.144*	(0.0585)
Constant	0.181***	(0.0527)
Observations	29,972	
R2	0.015	
F-test	21.43***	
Number of Fixed Effects	9,500	

Regression coefficients shown. Standard errors clustered at the physician level.
*** p<0.001, ** p<0.01, * p<0.05

Figures 6.4.B and 6.4.C depict the predicted probabilities of multihospital practice by each category of the number small and large PCI hospitals in a market. As expected, physicians in markets with more small PCI hospitals have a higher multihospital probability. The probability is 0.404 (95% CI, 0.386 to 0.421) in markets with 3 or more small PCI hospitals and 0.317 (95% CI, 0.307 to 0.327) in markets without small PCI hospitals.

Figure 6.4.A – Relation between the Average Bilateral Distance between Large PCI Hospitals in a Physician's Market and the Probability they will Multihospital Practice, 2001-2004

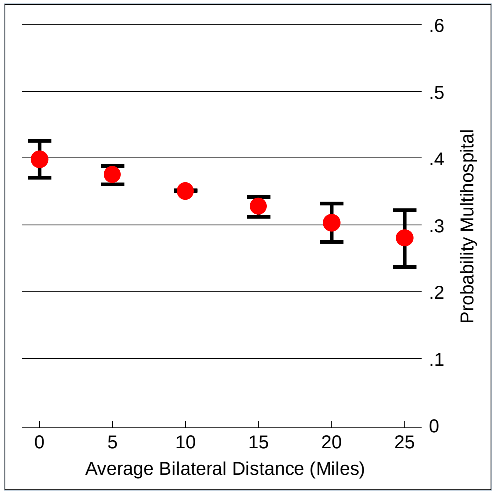


Figure 6.4.B – Relation between the Number of Small PCI Hospitals in a Physician's Market and the Probability they will Multihospital Practice, 2001-2004

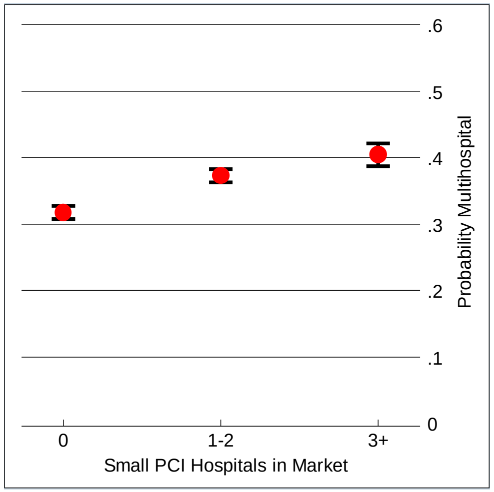
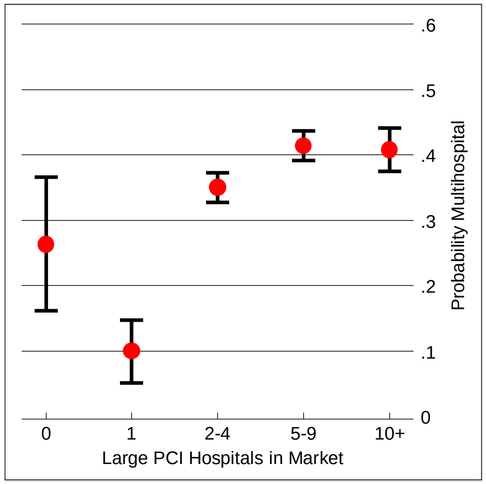


Figure 6.4.C – Relation between the Number of Large PCI Hospitals in a Physician's Market and the Probability they will Multihospital Practice, 2001-2004



Physicians in markets with only 1 large PCI hospital have a significantly lower probability of multihospital practice compared to any other market, including markets with 0 large PCI hospitals. The predicted probability for physicians in these markets is 0.099 (95% CI, 0.050 to 0.147), whereas physicians in markets with 0 large PCI hospitals have a predicted multihospital probability of 0.263 (95% CI, 0.161 to 0.365) and physicians in markets with 2 large PCI hospitals have a predicted probability of 0.350 (95% CI, 0.327 to 0.372). Categories of large PCI hospitals above 2 do not demonstrate a significant difference with the 2 PCI hospital category, suggesting that what really matters is that there is at least more than 1 large PCI hospital in the market. Though, visually it appears that physicians in markets with more large PCI hospitals should have higher probabilities of multihospital practicing.

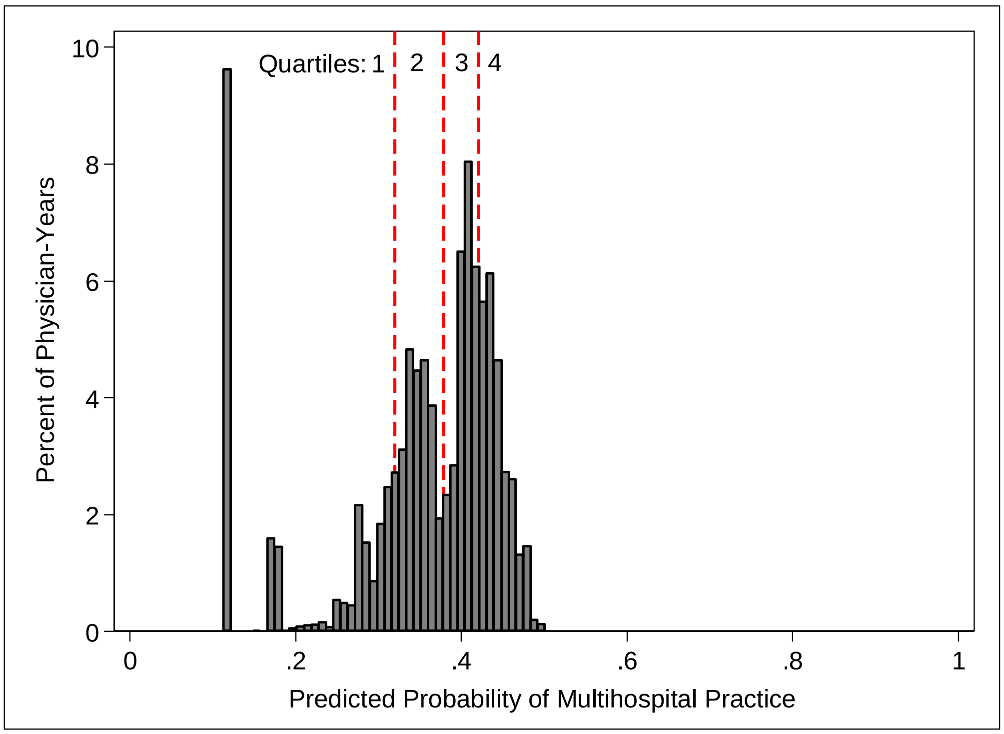
Taken together, the instruments I use to predict multihospital practice are not weak. As shown in Table 6.3, the F-test statistic from the model is 21.43 ($p < .001$), indicating that the instruments jointly predict multihospital practice with (more than) sufficient strength[25].

Finally, I use the estimates in Table 6.3 to predict the probability of multihospital practice ($\widehat{MH}_{jt}$) for each physician-year in my study sample. Figure 6.5 shows the distribution of $\widehat{MH}_{jt}$. At the very bottom of the distribution, 9.6% of the study sample is massed at a predicted probability of 0.1129. These physicians make up roughly ¼ of the first quartile of the probability distribution. Returning to the estimates in Table 6.3, it's clear that this mass is composed of physicians in markets with 1 large PCI hospital and 0 small PCI hospitals. The first quartile ranges from this mass up to 0.32. The next 2

[25] F-test statistics below 10 indicate "weak" instruments without sufficient predictive ability.

quartiles have much smaller ranges: quartile 2 goes from 0.32 to 0.379, and quartile 3 goes from 0.379 to 0.421. Quartile 4 extends to a maximum predicted probability of 0.501. The quartile ranges are shown in Figure 6.5 with red-dashed lines. Returning again to Table 6.3, physicians at the top of distribution would have been located in markets with 4 or 5 large PCI hospitals in extremely close proximity, with 3 or more small PCI hospitals also located within 25 miles of the physician's office location.

Figure 6.5 – Distribution of the Predicted Probability of Multihospital Practice



Chapter 7: Multihospital Practice, Patient Injury and Death

The consequence of multihospital practice is the physician works with more hospital teams, which reduces the shared experience between physicians and hospitals, limits the availability of physicians before and after procedures, and potentially reduces the mutual investments physicians and hospitals make to improve the quality of their service lines. These factors could increase the risk of medical errors being made during a patient's hospital stay and contribute to adverse outcomes such as death[26]. Figure 7.1 depicts my conceptual model on the relation between instrumented (or corrected) multihospital practice, patient injury and death.

This chapter describes the relation between multihospital practice by PCI physicians and adverse patient outcomes, including: injuries during the patient's hospital stay and patient mortality following PCI. First, I explain why multihospital practice can contribute to adverse patient outcomes. Next, I describe the patient outcomes I study and my empirical approach. And fourth, I review the results.

The Relationship between Multihospital Practice and Adverse Patient Outcomes

The consequence of multihospital practice by physicians is there are more physician-hospital teams delivering hospital procedures—at least as many as the number of hospitals physicians work in[27]. If a physician delivers procedures in 3 different hospitals in a given year, then at least 3 different physician-hospital teams must come

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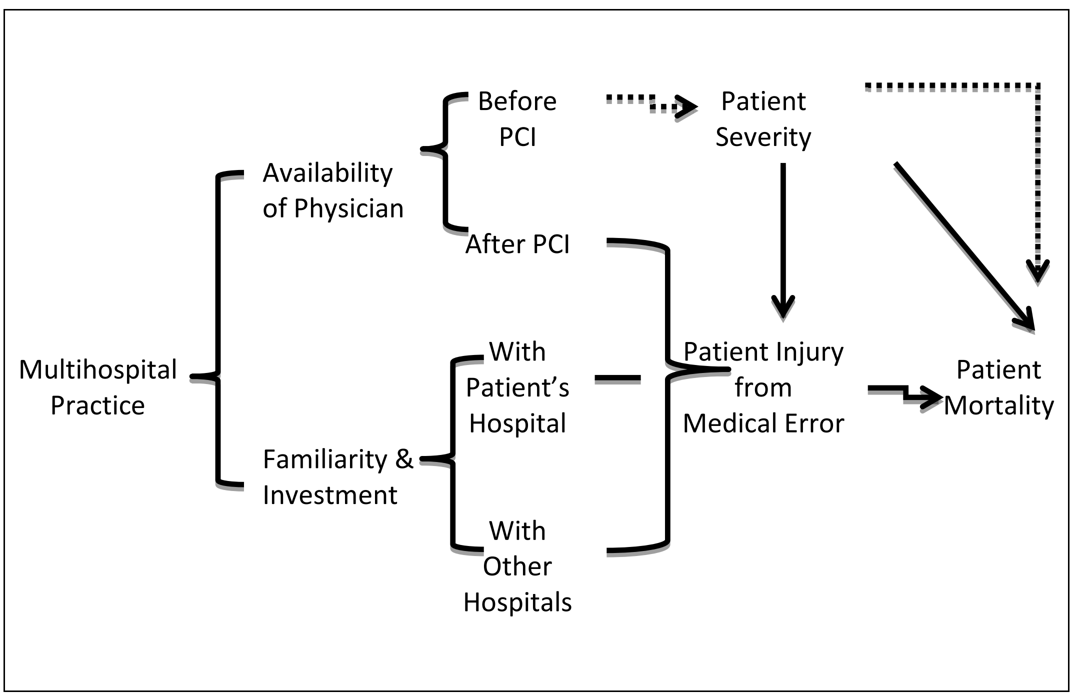
[26] The number of deaths resulting from medical errors is not precisely known, but recent estimates peg medical error as the third leading cause of death in the United States after heart disease and cancer (Makary & Daniel, 2016).
[27] There are likely more physician-hospital teams overall due to rotating staff within hospitals. My data do not capture the unique number of teams inside hospitals, only across hospitals. This means I only observe the minimum number of physician-hospital teams.

together to deliver those procedures. This has several implications that can adversely affect patients' outcomes.

First, multihospital practice creates varying levels of familiarity and investment with the physicians' hospitals. This consequence is depicted in the lower branch of Figure 7.1. Overall experience (i.e., procedure volume) has an inverse relation with adverse patient outcomes like inpatient mortality (Halm, 2002; H. S. Luft et al., 1979). Physicians learn procedures by doing them, and the more they do the better they become (i.e., practice makes perfect). However, evidence suggests that the improvement in patient outcomes from experience varies across physician-hospital teams (Huesch, 2011; Pisano, Bohmer, & Edmondson, 2001), and increases as physicians gain more experience with a specific hospital (Carey et al., 2008; Huckman & Pisano, 2006; Ramanarayanan, 2008).

Figure 7.1 – Conceptual Model on Multihospital Practice, Patient Injury and Death



A multihospital physician's experience in a patient's hospital is lower than it could be, and the experience they do have likely decays between their hospital work stints. More time spent in a specific hospital builds physician familiarity with a hospital's resources, making the physician-hospital team more effective at managing their patient's care (Huckman & Pisano, 2006). By dividing their time across multiple hospitals, instead of just working in 1, multihospital physicians will have less experience working with each hospital's staff, equipment and process of care. In addition, experience is believed to decay rapidly between hospital procedures[28] (Hockenberry, Lien, & Chou, 2008). Working across multiple hospitals introduces a periodicity to a physician's hospital experience, where the time between their work stints in a hospital can be erratic and long. Compared to solo-hospital physicians, multihospital physicians are continuously forgetting hospital-specific experience: while they practice in 1 hospital, they are simultaneously forgetting their experience in other hospitals.

While familiarity with a patient's hospital may be lower than it could be, multihospital physicians do build procedure experience in other hospitals. These additional procedures may improve physician skills and abilities generally (regardless of hospital) and may make multihospital physicians less likely to cause medical errors and injure their patients. As shown in Figure 7.1, familiarity in other hospitals can also influence patient injuries from medical errors.

The second consequence of multihospital practice is that it raises the time cost of delivering procedures (Miller et al., 1996; MV Pauly, 1978) and can lead to substitution of other hospital resources (e.g., other physicians, more tests) for the physician's own

[28] The benefit from prior volume has been found to depreciate within 15-21 days of a physician's last procedure.

direct care and supervision. With their practices split across more than 1 hospital, multihospital physicians will more often rely on other physicians and hospital staff to care for their patients[29]. These transfers of care have been linked to higher rates of inpatient mortality (Fisher et al., 2007; Norcini, Boulet, Opalek, & Dauphinee, 2013), where it is believed that more errors are made when hospital care is delivered by more physicians and staff. As shown in the top branch of Figure 7.1, the availability of the physician after a PCI should be related to differences in patient injuries from medical error.

Figure 7.1 also shows that the availability of the physician before emergent procedures may matter. Hospitals with 24-hour PCI services will have PCI physicians on-site and will be able to respond to emergent or transfer patients more quickly compared to hospitals that need to call-in PCI staff. The time-to-balloon (i.e., the time from patient arrival at the hospital to the PCI) has been shown to have significant effects on patient survival (Aversano et al., 2002; Nallamothu et al., 2007). Hospitals without 24 hour staff may be more reliant on multihospital physicians to staff their emergent PCI services, creating longer times-to-balloon for patients seen by these physicians. In this way, multihospital practice can influence the severity of the patient and contribute to differences in patient mortality directly. Figure 7.1 depicts this influence with a dashed line connecting the availability of the physician before a PCI to patient severity, which is then connected directly to patient mortality. The line is dashed because this additional severity is unobserved.

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[29] I find that multihospital physicians will occasionally practice in multiple hospitals on a single day. See my working paper, "Patient Mortality Risk on Days Interventional Cardiologists Deliver PCI in More Than 1 Hospital".

Third, the physician-hospital relationship has traditionally been a symbiotic one: hospitals rely on physicians to bring patients into their facilities and physicians rely on hospitals for investments that benefit their patients (e.g., talented staff, new technology) and their practices (e.g., lean management). When the physician is more committed to 1 hospital, we expect to see greater investments by that hospital in the physician's practice and stronger citizenship behavior on the part of the physician in that hospital (Roemer & Friedman, 1971) . For example, when hospitals play a larger role in the professional lives of their physicians (as would be the case with solo-hospital physicians) they are believed to be more effective at aligning physicians toward organizational goals like improved care quality. Evidence suggests that hospitals with more involvement from their physicians in designing (and adhering to) their processes of care have lower mortality rates (Knaus, Draper, Wagner, & Zimmerman, 1986). For physicians, greater affiliation with a hospital can spur hospital investments in their practices (i.e., training, new technology) and can elicit more prestige from other physicians within the hospital (Harris, 1977; M Pauly & Redisch, 1973), factors that improve their access to resources within a hospital and influence the quality of care they can offer their patients. This influence is depicted in the lower branch of Figure 7.1.

Adverse Patient Outcomes

I study two groups of adverse patient outcomes. First, I see if multihospital practice is related to the occurrence of injuries during a patient's hospital stay for PCI. My conceptual model (Figure 7.1) is that multihospital practice creates conditions in which medical errors are more likely. Medical errors are not recorded in Medicare claim records. However, injuries can be identified using information recorded in the patient's hospital claim. Using an algorithm developed by the Society of Actuaries (Shreve, van den Bos, & Gray, 2010), I culled the ICD-9 codes from the hospital claim records and flagged injuries that occurred during hospital stays for each patient. Each injury was assigned a probability that it occurred due to a medical error. Appendix Table A.7.1 describes the frequency of the top 20 types of injury in my study sample along with their error probability classifications. Next, I identified two subgroups of injury: those *unlikely* due to medical error and those *likely* due to medical error. Injuries unlikely due to medical error were those with a less than 10% chance of being caused by a medical error. Injuries likely due to a medical error were those classified with an above 90% chance of being caused by a medical error. The most common type of injury considered unlikely due to a medical error was "other complications of internal device", while the most common type of injury considered likely due to a medical error was "accidental puncture or laceration during a procedure", or *punctures*.

I defined four injury outcomes, these are:

(i) $Any\ Injury_{ijht}$, which is a dichotomous indicator equal to 1 if the patient had any injury during their hospital stay for PCI i of physician j delivered in hospital h in year t.
(ii) $Unlikely\ Error_{ijht}$, which is a dichotomous indicator equal to 1 if the patient had any injury that was unlikely caused (< 10% chance) by a medical error during their hospital stay for PCI i of physician j delivered in hospital h in year t.

(iii) $Likely\ Error_{ijht}$, which is a dichotomous indicator equal to 1 if the patient had any injury that was likely caused (> 90% chance) by a medical error during their hospital stay for PCI i of physician j delivered in hospital h in year t.

(iv) $Punctures_{ijht}$, which is a dichotomous indicator equal to 1 if the patient experienced an accidental puncture or laceration during their hospital stay for PCI i of physician j delivered in hospital h in year t.

Taken together, the set of injury outcomes works like a falsification test of whether multihospital practice creates conditions where more medical errors occur. Specifically, multihospital practice should be related to any injury occurring, but this will be so because of injuries due to medical error. Because all patients suffer some risk of injury, injuries unlikely due to medical error should not be related to whether the patient's physician is multihospital or not.

While the algorithm from the Society of Actuaries identifies patient injuries and classifies them medical errors, it's possible that errors specifically associated with PCI may not be captured by the algorithm or by its selection of ICD-9 codes. For example, care-coordination information regarding post-discharge care not be properly communicated to the patient is not something captured by the algorithm, but this would qualify as an error that could lead to an adverse-outcome. Therefore, my window into patient injury from medical errors is limited. That being said, it's likely that errors occur more often for the same physicians and hospitals, so by capturing some errors I am likely identifying the providers that create other errors I do not directly observe. Therefore, while I do face a limitation into which errors I can observe, the algorithm is likely sufficient for seeing which providers are more likely to cause medical errors (generally).

The second group of adverse patient outcomes I study is patient mortality. My conceptual model is that multihospital practice creates situations in which medical errors are more likely and a consequence of those errors is patient death. In addition, multihospital practice can influence patient severity through the availability of the physician before PCI, directly contributing to differences in patient death. I define four mortality outcomes:

(v) $Inhospital_{ijht}$, which is a dichotomous indicator equal to 1 if the patient died during their hospital stay for PCI i of physician j delivered in hospital h in year t.

(vi) $10\ Days\ after\ PCI_{ijht}$, which is a dichotomous indicator equal to 1 if the patient died within 10 days of PCI i performed by physician j in hospital h in year t.

(vii) $30\ Days\ after\ PCI_{ijht}$, which is a dichotomous indicator equal to 1 if the patient died within 30 days of PCI i performed by physician j in hospital h in year t.

(viii) $10\ Days\ after\ Discharge_{ijht}$, which is a dichotomous indicator equal to 1 if the patient died within 10 days of their discharge from hospital h after PCI i delivered by physician j in year t.

Inhospital mortality should pick on adverse outcomes occurring while the patient was under supervision at the hospital. Mortality 10 days after discharge will pick up on adverse outcomes occurring after the patient has left the direct supervision of the physician and hospital, and may reflect mishandled post-discharge planning. Mortality 10 and 30 days after PCI should pick up both inhospital and post discharge mortality outcomes at different time points after PCI.

In the next section, I refer to all 8 outcomes (i-viii) generally as $Adverse\ Outcome_{ijht}$, which is a dichotomous indicator equal to 1 if the outcome occurred. However, each of the 8 outcomes are modeled and presented separately in the results section.

Empirical Approach

I estimate three models for each adverse outcome described above. First, I estimate a model without any fixed effect, allowing differences between hospitals and regions to be captured in the observable characteristics I include. This model is informative to patients, payers and primary care doctors evaluating where they might want to go for their PCI. I call this the “Base Model”.

Next, I add in a fixed effect for the physician’s HRR to control for regional differences in care quality that may influence my outcomes in unobserved ways. I call this the “Base Model with HRR Fixed Effects”. Regional planners will find the results from this model most interesting as it focuses on factors within a region that explain adverse patient outcomes following PCI. Third, I remove hospital and regional characteristics from the model (including the HRR effect) and include a hospital fixed effect. This model has fewer assumptions on controlling for unobserved factors at the hospital level and above, and is most useful to hospital administrators or catheterization laboratory directors evaluating how to staff their PCI service line and what characteristics (within hospital) are significantly related to adverse patient outcomes.

Base Model

I model the probability of an adverse outcome for PCI i of physician j delivered in hospital h in year t. The probability can be written as:

(Eq. 7.1)

$$Prob(Adverse\ Outcome_{ijht} = 1) = \beta_0 + \beta_1\widehat{MH}_{jt} + \beta_2\widehat{HHI}_{jt} + \beta_3X_{it} + \beta_4X_{jt} + \beta_5X_{ht} + \gamma_t + u_{ijht},$$

where $Adverse\ Outcome_{ijht}$ is a dichotomous indicator equal to 1 if the patient died while still in the hospital (0 if they were discharged alive). $Adverse\ Outcome_{ijht}$ is a function of instrumented multihospital practice ($\widehat{MH}_{jt}$) by physician j in year t and instrumented hospital market structure ($\widehat{HHI}_{jt}$) in physician j's market in year t. $Adverse\ Outcome_{ijht}$ is also a function of patient (X_{it}), physician (X_{jt}), and hospital (X_{ht}) characteristics, which I describe below, an indicator (γ_t for year t, and an error term u_{ijht} that is assumed to be iid. $\widehat{MH}_{jt}$ is the corrected multihospital practice measure from chapter 6 (above) believed to be not directly related to patient outcomes and $\widehat{HHI}_{jt}$ is an expected measure of hospital market structure also believed to be not directly related to patient outcomes, and is described below.

The patient characteristics (X_{it}) include the principal diagnosis (AMI or atherosclerosis), the admission source (emergency department, transfer or referral), the admission status (elective, urgent or emergent)[30], the patient's disease burden (i.e., comorbidities)[31], demographic characteristics (age, sex, race, SES), and features of the PCI they received, including the PCI type (PTCA, stenting, or both (Serruys et al., 1994)), which vessels were diseased (right, left), if it was a multivessel procedure (Hannan et al., 2010), whether a drug-eluting stent was used (after April 2003), and whether it was a weekend procedure (Bell & Redelmeier, 2001).

The physician (X_{jt}) characteristics capture their experience in year t (volume at hospital h, volume at other hospitals, years since medical school graduation), a tier-rank of their medical school (top 29 or not) or if they were trained outside of the US, and an indicator for rural office locations. The hospital (X_{ht}) characteristics capture the hospital's volume in year t, the hospital's level of cardiac investment (indicators for cardiac intensive care hospital status and cardiac surgery hospital status), and other factors believed to influence care quality: the number of full-time resident nurses (RNs) per bed, the ownership profile (for-profit, not for-profit, or government), teaching and system status, and the proportion of admissions from Medicaid.

My strategy is to estimate a linear probability model of Eq. 7.1 using two-stage probability inclusion (2SPI), where I sequentially estimate Eq. 6.1 from chapter 6, create $\widehat{MH}_{jt}$, then estimate Eq. 7.1 with $\widehat{MH}_{jt}$ included. Because Eq. 6.1 is at the physician-year level, while Eq. 7.1 is a PCI level model, I bootstrap the equations together by taking random samples of physician markets and estimating the sequence of equations, then

[30] Patient risk is substantially higher for AMI and emergent patients (a.k.a., primary PCI) versus patients admitted through a physician referral with atherosclerosis (a.k.a., elective PCI) (Peterson et al., 2010; Shahian et al., 2012).

[31] Comorbidity indicators were identified using the Healthcare Cost and Utilization Project's comorbidity software 3.0, which follows Elixhauser et al. (1998), "Comorbidity Measures for Use with Administrative Data."

repeating the process 500 times. This allows me to incorporate the error around $\widehat{MH}_{jt}$ into my estimates for Eq. 7.1, yielding more accurate standard errors for hypothesis testing.

Finally, I check the validity of the instruments I used in Z_{jt} by saving out the residual from Eq. 7.1 and regressing the residual on Z_{jt}. I can write this as

(Eq. 7.2) $u_{ijht} = \beta_0 + \beta_1 Z_{jt} + v_{ijht}$

After estimating Eq. 7.2, I then interpret the F-test statistic on whether Z_{jt} are jointly related to u_{ijht}. This approximates Hansen's test of overidentifying restrictions, which checks to see if at least 1 of my instruments in Z_{jt} is invalid—if at least 1 instrument retains a significant relationship with u_{ijht} in Eq. 7.1 (after controlling for its influence on $Adverse\ Outcomes_{ijht}$ through $\widehat{MH}_{jt}$), then I know the instrumental variable strategy failed. Passing the F-test (i.e., it is insignificant) is necessary for my instrumental variable strategy, but it is not sufficient to show that my instruments are valid. Validity is primarily based on the conceptual model, which can't be shown statistically. I perform several additional checks to see if any feature of my conceptual model is violated.

Instrumented Hospital Market Structure ($\widehat{HHI}_{jt}$)

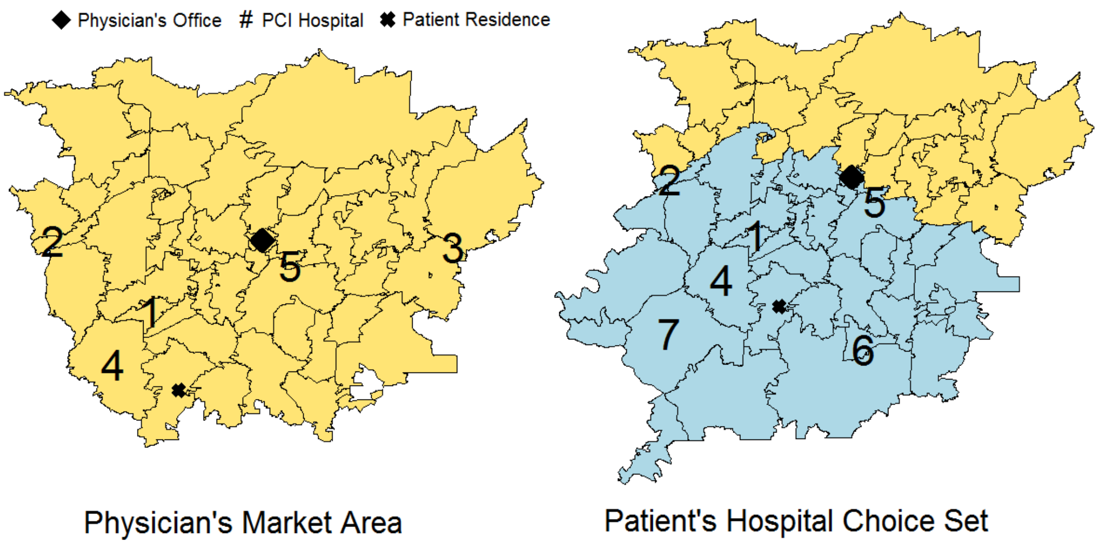
With many PCI programs entering and exiting between 2001 and 2004, hospital market structure was changing, making it necessary to control for changes in the level of hospital competition within physician markets over my study period. To do so, I include an instrumented measure of hospital market structure ($\widehat{HHI}_{jt}$) in Eq. 7.1 that is based on hospital demands (D_{ht}) estimated using patient distances to hospitals (d_{iht}). I use the following approach to create $\widehat{HHI}_{jt}$.

Demand for hospital h is equivalent to the volume of patients that picked it for their PCI during period t. Patient choice of hospital is believed to be a function of hospital quality, making observed hospital volumes inappropriate for defining D_{ht} in Eq. 1. Instead, D_{ht} can be formed by aggregating the probability hospital h was chosen by patients who considered it for their PCI i during period t. I define the set of hospitals considered by each patient as those located within 50 miles of their residence that were active during period t, where each hospital option has some probability of being picked by the patient for their PCI. Also included in their hospital set is an outside option, consisting of hospitals more than 50 miles from their residence.

Figure 7.2 depicts the hypothetical physician market B from Figure 1, where there were 5 PCI hospitals within 25 miles of the physician's office. Instead of using observed patient flows to these hospitals (which are believed to be endogenous) to form hospital demands, I estimate exogenous measures of demand (D_{ht}) by aggregating the probability patients picked hospital h for their PCI. Patients like the one shown with a small "x" in Figure 7.2 will consider all of the hospitals within 50 miles of their residence for their PCI i—which are the hospitals within the darker shaded zip codes in Figure 7.2. Patient x will consider the 6 hospitals shown surrounding their residence in the right panel of Figure 7.2, and they will select 1 of these hospitals (or the outside option) for their PCI. The probability patient x picked each of the 4 hospitals that are shared between the patient's hospital choice set and the physician's market area will be aggregated over all patients that considered these hospitals to form 4 of the 5 hospital demands in physician

j's market. Demand for the remaining 5th hospital (while not considered by patient x in Figure 2) is formed the same way from other patients within 50 miles of it and added to the set of hospital demands (D_{ht}) inside j's market.

Figure 7.2 – Visual Aid for Creating Patient Demands (D_{ht}) for Hospitals in the Physician's Market Area



I conceptualize the patient's choice of hospital in period t using the following utility maximization framework: a patient i will choose hospital h for their procedure when the utility they get from that choice, U_{iht}, is greater than the utility they get from any other hospital k in their choice set. Patients pick hospitals for a variety of reasons but (in general) they prefer higher quality hospitals and they prefer hospitals that are more convenient. Because it is unlikely that patients consider convenience to hospital h when they decide where to live, the distance (d_{iht}) from patient residence to hospital h is unrelated to hospital quality, making it an exogenous source of variation in estimating patient demand for hospitals.

I define a patient's utility (U_{iht}) function using only d_{iht}, which I can write as

(Eq. 7.3)
$$U_{iht} = \psi d_{iht} + \epsilon_{iht},$$

where ϵ_{ijht} is an error term assumed to be independent and identically distributed. When the patient's utility from choice h exceeds the utility from any other hospital k in their choice set, or $U_{iht} > U_{ikt}$, then the patient will select hospital h for their PCI i. Assuming a representative patient, I estimate Eq. 7.3 using a conditional logit model. The probability that hospital h will be chosen for PCI i ($\hat{\pi}_{iht}$) is:

(Eq. 7.4)
$$\hat{\pi}_{iht} = Prob(C_{iht} = 1) = \frac{e^{U_{iht}}}{\sum_k^K e^{U_{iht}}}$$

Where C_{iht} is a dichotomous indicator that equals 1 if hospital h was selected by patient i and 0 otherwise.

To form patient demands for each hospital (D_{ht}), I aggregate the predicted probability hospital h was chosen ($\hat{\pi}_{iht}$) across all i delivered in period t, or

(Eq. 7.5)
$$D_{ht} = \sum_i \hat{\pi}_{iht}$$

Because the set of D_{ht} in physician j's market are based on predicted probabilities—identified using variation in patient distances to hospitals—and not observed patient flows, they do not depend on unobserved hospital quality. I use the set of predicted hospital demands in each physician market (H_{jt}) to form instrumented measures of hospital market structure ($\widehat{HHI}_{jt}$). First, I form the total predicted demand for hospitals in market j during period t (D_{jt}) as $\sum_{h\in H_{jt}} D_{ht}$. Next, I use the standard Herfindahl index calculation:

(Eq. 7.6)

$$\widehat{HHI}_{jt} = \sum_{h\in H_{jt}} \left(\frac{D_{ht}}{D_{jt}} \times 100\right)^2$$

to form measures of instrumented hospital market structure in each market. I include indicators for quartiles of $\widehat{HHI}_{jt}$ in Eq. 7.1 to control for changes in hospital competition from 2001 through 2004. Quartile 1 represents the most competitive hospital markets and quartile 4 represents the most concentrated. By controlling for hospital competition, Eq. 7.1 allows me to observe the effect of instrumented multihospital practice on differences in the probability of adverse outcomes following PCI while controlling for differences in market quality driven by greater hospital competition.

<u>Fixed Effect Models</u>

I estimate two additional outcome models. First, I include a fixed effect for the physician's HRR to Eq. 7.1, which is

(Eq. 7.7)

$$Prob(Adverse\ Outcome_{ijht} = 1) = \beta_0 + \beta_1 \widehat{MH}_{jt} + \beta_2 \widehat{HHI}_{jt} + \beta_3 X_{it} + \beta_4 X_{jt} + \beta_5 X_{ht} + \gamma_t + \tau_r + u_{ijht},$$

Where everything else is exactly the same as Eq. 7.1, the only difference is that I have included the HRR fixed effect τ_r to the model.

Next, I remove all hospital characteristics except annual hospital PCI volume (i.e., experience), as well as the instrumented hospital market structure ($\widehat{HHI}_{jt}$) measure, and the HRR fixed effect, and include a hospital fixed effect. This can be written as

(Eq. 7.8) $$Prob(Adverse\ Outcome_{ijht} = 1) = \beta_0 + \beta_1 \widehat{MH}_{jt} + \beta_2 X_{it} + \beta_3 X_{jt} + \gamma_t + \tau_h + u_{ijht}$$

Where everything else from Eq. 7.1 is the same.

For both fixed effect models, I follow the same 2SPI methodology and bootstrap the first and second stage equations together to recover more accurate standard errors—which incorporate uncertainty around $\widehat{MH}_{jt}$ into the models of adverse patient outcomes.

Results

The analysis in this chapter is at the PCI level. Tables 7.1.A through 7.1.C present the average characteristics of PCIs overall, and by multihospital status: either "yes", the physician worked in multiple hospitals that year, or "no", the physician did not. Looking at patient characteristics, many important differences exist. Multihospital physicians perform PCI on relatively fewer patient's admitted with a principle diagnosis of AMI, seeing relatively more patients admitted for atherosclerosis—a less acute diagnosis. This is also apparent in the fact that multihospital physicians see fewer urgent or emergent patients and more outpatient or elective patients. Taken together, it looks like multihospital physicians do fewer primary PCI and more elective PCI. There are many other significant differences between patients, however, it is difficult to hypothesize what (if any) combined effect these differences might have on the relative severity levels between patients seen by multi or solo-hospital physicians.

Table 7.1.A – Average Patient Characteristics by Multihospital Status, 2001-2004

Characteristics	**Overall** N=1,027,230	PCI Delivered by a Multihospital Physician? **Yes** N=433,591 (42.2%)	**No** N=593,639 (57.8%)	*p*
Patient Demographics				
Age				
65 to 70	23.14%	23.15%	23.14%	0.83
70 to 75	26.80%	26.58%	26.96%	< .001
75 to 80	25.08%	25.02%	25.12%	0.22
80 to 85	16.86%	17.04%	16.74%	< .001
85 & Over	8.12%	8.21%	8.04%	< .01
Sex				
Male	57.49%	56.86%	57.96%	< .001
Female	42.51%	43.14%	42.04%	< .001
Race				
White	91.74%	91.28%	92.08%	< .001
African-American	4.76%	4.88%	4.67%	< .001
Asian	1.01%	1.03%	0.99%	< .05
Other Race	1.07%	1.00%	1.12%	< .001
Hispanic	1.42%	1.80%	1.14%	< .001
Patient Condition at Admission				
Primary Diagnosis				
AMI	27.65%	26.81%	28.27%	< .001
Atherosclerosis	72.35%	73.19%	71.73%	< .001
Admission Source				
Outpatient	7.28%	7.41%	7.19%	< .001
Physician Referral	52.23%	53.29%	51.45%	< .001
Emergency Dept.	24.59%	24.76%	24.47%	< .01
Transfer	15.90%	14.55%	16.89%	< .001
Admission Type				
Outpatient	7.28%	7.41%	7.19%	< .001
Inpatient Elective	35.59%	37.83%	33.95%	< .001
Inpatient Urgent	27.92%	25.87%	29.41%	< .001
Inpatient Emergent	29.21%	28.89%	29.44%	< .001
Procedure Characteristics				
PCI Type				
Stent Placement	85.80%	85.42%	86.08%	< .001
PTCA	11.00%	11.21%	10.84%	< .001
Both - PTCA & Stent	3.20%	3.36%	3.08%	< .001
Multivessel	10.39%	10.53%	10.29%	< .001
Vessels Indicated				
Right Coronary	31.02%	31.24%	30.85%	< .001
Left Coronary	24.51%	24.69%	24.38%	< .001
Left Descending	33.95%	34.19%	33.78%	< .001
Drug-Eluting Stent (Post April 2003)	28.74%	28.57%	28.87%	< .001
Weekend	7.61%	8.08%	7.27%	< .001
Patient Comorbidities				
Congestive Heart Failure	6.92%	7.16%	6.75%	< .001
Valvular Disease	2.54%	2.50%	2.57%	< .05
Pulmonary Circulation Disorder	0.42%	0.42%	0.41%	0.55
Peripheral Vascular Disease	14.84%	15.34%	14.47%	< .001
Hypertension	70.06%	69.97%	70.12%	0.11

Paralysis	1.46%	1.49%	1.44%	< .05
Other Neurological Disorders	2.51%	2.60%	2.45%	< .001
Chronic Pulmonary Disease	20.08%	20.41%	19.85%	< .001
Diabetes Without Complication	28.03%	28.16%	27.93%	< .01
Diabetes With Complications	4.19%	4.15%	4.23%	0.056
Hypothyroidism	10.43%	10.52%	10.36%	< .01
Renal Failure	3.89%	3.96%	3.85%	<.01
Liver Disease	0.51%	0.48%	0.52%	< .01
Chronic Peptic Ulcer Disease	0.10%	0.10%	0.10%	0.96
HIV and AIDS	0.01%	0.01%	0.01%	0.41
Lymphoma	0.42%	0.41%	0.43%	0.22
Metastatic Cancer	0.85%	0.84%	0.86%	0.36
Solid Tumor without Metastasis	2.69%	2.66%	2.72%	0.088
Rheumatoid Arthritis	2.18%	2.09%	2.25%	< .001
Coagulation Deficiency	3.11%	3.15%	3.09%	0.073
Obesity	6.45%	6.50%	6.42%	0.13
Weight Loss	1.04%	1.10%	0.99%	< .001
Fluid and Electrolyte Disorders	12.56%	12.96%	12.27%	< .001
Blood Loss Anemia	2.25%	2.27%	2.23%	0.22
Deficiency Anemias	11.29%	11.50%	11.14%	< .001
Alcohol Abuse	0.86%	0.86%	0.86%	0.94
Drug Abuse	0.15%	0.16%	0.15%	0.3
Psychoses	0.99%	1.01%	0.97%	0.057
Depression	4.76%	4.63%	4.86%	< .001

Physician and hospital characteristics of PCI also differ in important ways. Physician differences are shown in Table 7.1.B. PCI delivered by multihospital physicians are on average performed by physicians with less volume in the patient's hospital, but more overall PCI volume (which includes volume from other PCI hospitals). In addition, PCI delivered by multihospital physician are less likely to be from a physician that graduated from a top 29 medical school. Taken together, these factors suggest there may be some unfavorable physician selection into multihospital practices.

Table 7.1.B – Average Physician Characteristics by Multihospital Status, 2001-2004

Characteristics	**Overall** N=1,027,230	PCI Delivered by a Multihospital Physician? **Yes** N=433,591 (42.2%)	**No** N=593,639 (57.8%)	*p*
Unique Physicians, No.	9,500	4,139	7,826	--
PCI Hospitals Worked In	1.45	2.35	1	< .001
Annual PCI Volume				
Total	73.56	75.58	72.10	< .001
At Patient's Hospital	65.79	57.14	72.10	< .001
At Other Hospitals	7.78	18.44	0.00	< .001
Years Since MD	21.37	21.22	21.49	< .001
Medical School Training				
Top 29 MD School	19.92%	16.54%	22.40%	< .001
30+ Ranked MD School	50.57%	51.10%	50.18%	< .001
Foreign Trained	29.51%	32.36%	27.42%	< .001

Average differences in hospital characteristics between PCI are shown in Table 7.1.C. Compared to multihospital physicians, solo hospital physicians deliver relatively more PCI in higher volume hospitals, teaching hospitals, not-for profit hospitals, hospital with cardiac care or adult cardiac surgery programs, larger hospitals with more RNs per bed, and hospitals that see disproportionately fewer Medicaid admissions, which are all characteristics of higher quality hospitals. These differences suggest that there is unfavorable hospital selection into multihospital practice—hospitals that are less-invested in patient care and possibly of lower quality for their patients.

Table 7.1.C – Average Hospital Characteristics by Multihospital Status, 2001-2004

Characteristics	Overall N=1,027,230	PCI Delivered by a Multihospital Physician? **Yes** N=433,591 (42.2%)	**No** N=593,639 (57.8%)	p
Unique PCI Hospitals, No.	1,276	1,123	1,126	--
Hospital PCI Volume	445.32	406.24	473.87	< .001
Control Status				
Non-profit	79.56%	76.52%	81.79%	< .001
For-profit	13.02%	18.49%	9.01%	< .001
Government	7.42%	4.99%	9.19%	< .001
Teaching	27.80%	21.64%	32.30%	< .001
System	69.70%	74.33%	66.31%	< .001
Cardiac Intensive Care	79.28%	75.70%	81.90%	< .001
Adult Cardiac Surgery	23.33%	23.31%	23.35%	0.57
Hospital Beds	459.67	423.81	485.86	< .001
RNs per Bed	1.48	1.44	1.52	< .001
Medicaid Share of Admissions	14.28%	14.34%	14.24%	< .001

Table 7.2.A describes the conditional logit model used to create instrumented hospital market structure ($\widehat{HHI}_{jt}$). 7.2.A shows that on average patients had 12 hospitals to choose from in their hospital choice sets (not including the outside option of a hospital beyond 50 miles from their residence). On average, hospitals were 26 miles from their residence. For just over 60,000 PCIs (5.9%), there was no "inside" hospital option to pick from, meaning that the patient lived more than 50 miles from the nearest PCI hospital. These PCI were not included in the model estimates in 7.2.B. Also, for the remaining PCI with an inside option, just over 12% picked the outside hospital—or in other words, 12% of patients picked a PCI hospital that was more than 50 miles from their residence.

Table 7.2.A – Characteristics of PCI Hospital Choice Sets for Patients

Characteristics of PCI Hospital Choice Sets	N or Mean
Total number of PCI	1,027,230
Choice sets for PCI with	
At least 1 inside hospital option (valid sets)	966,227
Outside option picked by patient (% of valid sets)	117,843 (12.19%)
Outside option only (invalid sets)	61,003
Characteristics of choice sets with at least 1 inside option	
Average number of hospitals within choice set, excluding the outside option (sd)	12.06 (12.59
Average distance (miles) to hospitals (sd)	26.3 (10.42)

Table 7.2.B shows patients have a distaste for hospitals that are farther from their homes. A one mile increase in the distance from the patient's home to a PCI hospital lowers the probability they will pick that hospital by 0.85 percentage points. Using this relation, I create hospital demands (D_{ht}) and instrumented hospital market structure ($\widehat{HHI}_{jt}$) for each physician market in each year.

Table 7.2.B – Conditional Logit Regression

	Coef. (SE) dy/dx (SE)
Distance from Patient Residence to Hospital	-0.0474*** (0.000078) -0.0085*** (6.86e-06)
Observations	12,620,311
Pseudo R2	0.0979

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Injury Models

Table 7.3.A shows the prevalence of injury outcomes over 2001-2004. Roughly 10 to 11% of PCI patients have an injury during their hospital stay. Injuries unlikely due to medical errors constitute most of these and are relatively consistent at 6.5% of PCIs over the study period. Injuries likely due to medical error are less frequent (less than 2%) and they become less so over the study period. This appears to be driven by fewer punctures and declines most sharply in 2003[32].

Table 7.3.A – Prevalence of Injury Outcomes, 2001-2004

Year	PCI	% Any Injury	% Any Injury Unlikely Due to Medical Error	% Any Injury Likely Due to Medical Error	% Puncture
2001	230,434	11.37%	5.91%	1.86%	1.43%
2002	235,574	11.71%	6.45%	1.76%	1.32%
2003	269,352	11.71%	7.06%	1.32%	0.88%
2004	291,870	10.81%	6.45%	1.23%	0.84%
All Years	1,027,230	11.38%	6.49%	1.52%	1.09%

Table 7.3.B shows average injuries by physicians that were in quartile 4 of instrumented multihospital practice ($\widehat{MH}_{jt}$) compared to physicians in quartile 1. This compares physicians that were "most likely" to be multihospital in year t compared to physicians that were "least likely" to. The table presents observed and expected averages. The observed average shows injury rates without any adjustment (e.g., for patient characteristics). The expected average shows the predicted injury rates based only on patient characteristics. To find the expected rates, I model the probability of each injury outcome with a logistic regression of injury on just the characteristics shown in Table 7.1.A. I use the entire study sample.

[32] 2003 was the year drug-eluting stents were introduced.

Table 7.3.B shows that observed injury rates are higher among physicians most likely to multihospital practice. Expected injury rates are also higher (except for punctures), but the difference is very slight. And while it is statistically different, the expected rates appear to be almost the same. For example, the puncture rate among the most likely multihospital physicians is 1.09%, while the puncture rate among the least likely multihospital physicians is 1.10%, a difference of 0.01 percentage points. The difference in observed puncture rates between the two groups is 0.27 percentage points. If we consider the expected rates to be measures of patient severity, Table 7.3.B suggests that patient severity is seemingly even between quartile 1 and quartile 4 of the instrumented multihospital practice probability distribution.

Table 7.3.B -- Average Observed and Expected Injury Outcomes by Instrumented Multihospital Quartile ($\widehat{MH}_{jt}$): Most Likely Multihospital (Quartile 4) vs. Least Likely Multihospital (Quartile 1)

		PCI "Likely" Delivered by a Multihospital Physician?		
		Yes	**No**	
		($\widehat{MH}_{jt}$ Quartile 4)	($\widehat{MH}_{jt}$ Quartile 1)	
Characteristics	**Overall** N=1,027,230	N=307,418 (29.93%)	N=198,223 (19.30%)	p
Any Injury				
Observed	11.38%	12.49%	11.28%	< .001
Expected	11.38%	11.47%	11.42%	< .001
Any Injury Unlikely Due to Medical Error				
Observed	6.49%	7.24%	6.43%	< .001
Expected	6.49%	6.55%	6.51%	< .001
Any Injury Likely Due to Medical Error				
Observed	1.52%	1.61%	1.59%	.616
Expected	1.52%	1.53%	1.52%	< .001
Puncture				
Observed	1.09%	1.45%	1.18%	.261
Expected	1.09%	1.09%	1.10%	< .05

Table 7.4.A presents my base model (Eq. 7.1) estimates on the relation between patient injury and instrumented multihospital practice ($\widehat{MH}_{jt}$). The model coefficients shown in the table were selected from the full set of coefficients from each model to keep the presentation concise. The full model for each injury outcome is available in Appendix Tables A.7.2.1 through A.7.2.4.

What is shown in Table 7.4.A, as well as the other outcome tables in this chapter, are the quartile indicator estimates of $\widehat{MH}_{jt}$, annual physician PCI volume estimates (at the patient's hospital, and at other hospitals), estimates for the number of years since the physician finished medical school and annual hospital PCI volume, and estimates for each category of instrumented hospital market structure ($\widehat{HHI}_{jt}$).

Table 7.4.A—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Injury Occurring during the Patient's Hospital Stay for PCI, Without Fixed Effects

VARIABLES	(1) Any Injury	(2) Any Injury Unlikely Due to Error	(3) Any Injury Likely Due to Error	(4) Punctures
Multihospital Physician ($\widetilde{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	-0.00408	-0.00280	-0.000957	-0.000797
	(0.00348)	(0.00272)	(0.00105)	(0.000971)
Quartile 3	-0.00192	-0.000703	-0.000658	-0.000623
	(0.00577)	(0.00439)	(0.00146)	(0.00129)
Quartile 4	0.00795	0.00798	0.000753	0.000973
	(0.00636)	(0.00492)	(0.00169)	(0.00155)
Physician Annual PCI Volume				
In the Patient's Hospital	-8.90e-05***	-3.29e-05	-1.85e-05***	-1.56e-05***
	(2.03e-05)	(1.78e-05)	(4.43e-06)	(4.20e-06)
In Other Hospitals	-0.000122**	-9.00e-05**	-2.18e-05**	-1.69e-05*
	(3.81e-05)	(2.86e-05)	(7.74e-06)	(7.27e-06)
Hospital Annual PCI Volume	-1.85e-06	2.26e-06	3.41e-06*	2.87e-06
	(5.12e-06)	(3.96e-06)	(1.66e-06)	(1.67e-06)
Years as MD	-0.000213*	-9.96e-05	-7.34e-05**	-6.37e-05**
	(9.65e-05)	(7.59e-05)	(2.60e-05)	(2.40e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)				
Category 1: 0 to 1250 (Ref)	--	--	--	--
Category 2: 1250 to 2500	0.00858	0.0102**	0.000737	0.00122
	(0.00447)	(0.00346)	(0.00115)	(0.00105)
Category 3: 2500 to 5000	0.00393	0.00763	0.000934	0.00149
	(0.00551)	(0.00402)	(0.00136)	(0.00122)
Category 4: 5000 to 10000	0.00516	0.00639	0.00270	0.00320*
	(0.00577)	(0.00431)	(0.00150)	(0.00137)
Category 5: 0 PCI Hospitals in Market	-0.00798	-0.00133	0.000341	0.000907
	(0.00893)	(0.00641)	(0.00213)	(0.00189)
Observations	1,027,230	1,027,230	1,027,230	1,027,230
R2	0.024	0.016	0.006	0.003

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

I find a significant relation between patient injury and annual physician PCI volume: physicians with more volume in a patient's hospital or other hospitals are associated with a lower probability of patient injury. Physician years since medical school also matters, where more tenured physicians are associated with a lower probability of injury. Whether a physician is (predicted to be) multihospital or not does not appear to be related to patient injury. Instrumented hospital market structure also does not show a significant relation with patient injury, except for punctures being more likely in the most consolidated hospital markets.

Table 7.4.A also shows that the relation between injury and annual physician PCI volume in a patient's hospital appears to be driven by medical error. This can be seen by comparing the coefficients in column 2 to column 3: injury unlikely due to medical error is insignificant, while injury likely due to medical error is significant. And it appears that punctures (the most common medical error) are driving the medical error result.

The HRR fixed effect estimates are shown in Table 7.4.B. Appendix tables A.7.3.1 through A.7.3.4 present the full models. Including a fixed effect for the physician's HRR changes the findings in Table 7.4.A in several ways. First, physician PCI volume in other hospitals does not appear to matter anymore, suggesting that the correlation between other hospital volume and patient injury reflects differences between regions and not a causal relation. Second, hospitals with more annual PCI volume are now associated with a higher probability of patient injury from medical error—most likely driven by a higher probability of puncture. This suggests that hospital volume within region is an important characteristic to consider with regards to puncture and other medical errors, but in general, hospital volume without consideration of the region would not be very useful. The other results are the same: multihospital practice ($\widetilde{MH}_{jt}$) holds no significant relation with patient injury, but greater physician volume in a patient's hospital is associated with a lower probability of medical error.

Table 7.4.B—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Injury Occurring during the Patient's Hospital Stay for PCI, With HRR Fixed Effects

VARIABLES	(1) Any Injury	(2) Any Injury Unlikely Due to Error	(3) Any Injury Likely Due to Error	(4) Punctures
Multihospital Physician ($\widetilde{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	-0.00243	-0.00289	-0.000763	-0.000461
	(0.00421)	(0.00324)	(0.000966)	(0.000908)
Quartile 3	-0.00414	-0.00643	-0.000619	-0.000224
	(0.00536)	(0.00408)	(0.00121)	(0.00112)
Quartile 4	0.00262	5.67e-05	0.000694	0.00140
	(0.00564)	(0.00429)	(0.00142)	(0.00135)
Physician Annual PCI Volume				
In the Patient's Hospital	-7.10e-05***	-1.69e-05	-1.49e-05***	-1.19e-05***
	(1.80e-05)	(1.52e-05)	(3.73e-06)	(3.33e-06)
In Other Hospitals	-7.33e-05*	-4.86e-05	-8.82e-06	-6.82e-06
	(3.07e-05)	(2.81e-05)	(6.87e-06)	(6.11e-06)
Hospital Annual PCI Volume	2.32e-06	6.74e-06	6.47e-06***	5.56e-06***
	(4.73e-06)	(3.71e-06)	(1.29e-06)	(1.34e-06)
Years as MD	-0.000152	-6.23e-05	-9.37e-05***	-8.56e-05***
	(8.07e-05)	(6.25e-05)	(2.25e-05)	(2.03e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)				
Category 1: 0 to 1250 (Ref)	--	--	--	--
Category 2: 1250 to 2500	-0.00514	-0.00374	-0.000364	0.000227
	(0.00459)	(0.00342)	(0.00113)	(0.00101)
Category 3: 2500 to 5000	-5.34e-05	0.00223	0.00165	0.00215
	(0.00622)	(0.00476)	(0.00148)	(0.00140)
Category 4: 5000 to 10000	-0.00985	-0.00775	0.00185	0.00279
	(0.00657)	(0.00489)	(0.00162)	(0.00151)
Category 5: 0 PCI Hospitals in Market	-0.0199*	-0.0127	-0.00125	-0.000378
	(0.00882)	(0.00652)	(0.00225)	(0.00205)
Observations	1,027,230	1,027,230	1,027,230	1,027,230
R2	0.022	0.015	0.006	0.003
HRR Fixed Effects, No.	305	305	305	305

Regression coefficients shown. Standard errors clustered at the HRR level.
*** $p<0.001$, ** $p<0.01$, * $p<0.05$

The hospital fixed effect estimates are shown in Table 7.4.C. Appendix tables A.7.4.1 through A.7.4.4 present the full models. They are consistent with the HRR fixed effect estimates except that hospital PCI volume is no longer significantly related to patient injury. This suggests that the within region relation between hospital volume and injury was masking some other fixed difference between the scale of a hospital's PCI program and the occurrence of medical errors. Within a hospital, the annual PCI volume does not appear to be significantly related to injuries. One possibility is that larger PCI hospitals are also "learning" centers, where more injuries due to medical errors could be expected because the physicians and technical staff are training. Some evidence supports this idea: in the base model and the model with HRR fixed effects, teaching hospitals are associated with a higher probability of patient injury from medical error. Within a hospital, physicians will have different levels of PCI volume (i.e., within hospital experience) and medical errors are more likely when a patient's physician is less experienced in their hospital.

Table 7.4.C—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Injury Occurring during the Patient's Hospital Stay for PCI, With Hospital Fixed Effects

VARIABLES	(1) Any Injury	(2) Any Injury Unlikely Due to Error	(3) Any Injury Likely Due to Error	(4) Punctures
Multihospital Physician ($\widetilde{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	0.000232	-0.000734	-0.000367	-0.000257
	(0.00298)	(0.00229)	(0.000820)	(0.000728)
Quartile 3	0.00175	-0.00142	-0.000664	-0.000370
	(0.00382)	(0.00251)	(0.00105)	(0.000951)
Quartile 4	0.00702	0.00410	0.000384	0.000952
	(0.00384)	(0.00275)	(0.00121)	(0.00110)
Physician Annual PCI Volume				
In the Patient's Hospital	-7.96e-05***	-2.42e-05*	-1.58e-05***	-1.18e-05***
	(1.28e-05)	(9.84e-06)	(4.02e-06)	(3.25e-06)
In Other Hospitals	-6.78e-05**	-4.13e-05	-1.41e-05*	-1.15e-05
	(2.48e-05)	(2.24e-05)	(6.62e-06)	(5.89e-06)
Hospital Annual PCI Volume	2.26e-06	-5.05e-06	3.57e-06	2.15e-06
	(8.08e-06)	(6.18e-06)	(2.61e-06)	(2.33e-06)
Years as MD	-0.000145*	-3.66e-05	-8.91e-05***	-8.31e-05***
	(7.05e-05)	(5.33e-05)	(2.30e-05)	(2.04e-05)
Observations	1,027,230	1,027,230	1,027,230	1,027,230
R2	0.021	0.015	0.006	0.003
Number of Fixed Effects	1,276	1,276	1,276	1,276

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table 7.5 contains the F-test statistics and p values estimates for Eq. 7.2, which regresses the overall error, u_{ijht} on my set of instruments, Z_{jt}. The F-test checks to see if the instruments are jointly related to u_{ijht}. Table 7.5 shows this to be the case for my base model (without fixed effects), as well as for the any injury model. Based on the test statistics in Table 7.5, only the HRR and hospital fixed effect models for injuries likely due to medical error and punctures pass the validity check of not being overidentified. Without controlling for region (or hospital, which is nested in regions), the instruments hold a relation with something unobserved in the error term.

Table 7.5 – Injury Model F-tests for Overidentification

VARIABLES	(1) Any Injury	(2) Any Injury Unlikely Due to Error	(3) Any Injury Likely Due to Error	(4) Punctures
Base Model (without FEs)				
F-test	17.66***	11.80***	7.80***	8.90***
p	0.0000	0.0000	0.0000	0.0000
HRR Fixed Effects				
F-test	2.70**	1.96*	0.88	0.66
p	0.0057	0.0473	0.5351	0.7259
Hospital Fixed Effects				
F-test	2.41*	1.01	0.52	0.44
p	0.0133	0.4245	0.8427	0.8946

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

Mortality Models

Table 7.6.A shows the prevalence in mortality outcomes over 2001-2004. 30 day mortality after PCI occurs for roughly 2.5% of patients, and over my study period that mortality rate drops significantly. In 2001 it was 2.68% and by 2004 it was 2.32%, a decline of 13%. Published 30 day mortality rates after PCI were slightly higher (3.3% in 1997) 4 years prior to the start of my study period (McGrath, 2000), indicating that the

fall in mortality had been occurring prior to 2001. This significant decline appears to have come entirely from fewer inhospital deaths. Mortality 10 days after PCI tracks very closely to inhospital death. While post discharge death (within 10 days) appears to be a smaller portion patient mortality—just under 0.5% of patients die in the 10 days after discharge—and it does not appear to diminish over time.

Table 7.6.A – Prevalence of Mortality Outcomes, 2001-2004

Year	PCI	% Inhospital Mortality	% 10 Day Mortality after PCI	% 30 Day Mortality after PCI	% 10 Day Mortality after Discharge
2001	230,434	1.95%	1.90%	2.68%	0.43%
2002	235,574	1.87%	1.87%	2.61%	0.45%
2003	269,352	1.73%	1.73%	2.49%	0.46%
2004	291,870	1.58%	1.60%	2.32%	0.44%
All Years	1,027,230	1.77%	1.77%	2.51%	0.45%

Table 7.6.B presents observed and expected mortality rates for PCI delivered by physicians that were most likely (quartile 4) to be multihospital compared to physicians that were least likely to be (quartile 1). Observed mortality rates (i.e., unadjusted) are higher among physicians that were most likely to be multihospital. For example, inhospital mortality is 4.4% percent higher. Expected mortality rates (created like the expected injury rates in Table 7.3.B above) are similar between the two groups. This suggests that patient severity (based on observed patient characteristics) is balanced between the highest and lowest quartiles of the instrumented multihospital practice probability distribution.

Table 7.6.B – Average Observed and Expected Mortality Outcomes by Instrumented Multihospital Quartile ($\widetilde{MH}_{jt}$) : Most Likely Multihospital (Quartile 4) vs. Least Likely Multihospital (Quartile 1)

Characteristics	**Overall** N=1,027,230	PCI "Likely" Delivered by a Multihospital Physician? **Yes** ($\widetilde{MH}_{jt}$ Quartile 4) N=307,418 (29.93%)	**No** ($\widetilde{MH}_{jt}$ Quartile 1) N=198,223 (19.30%)	p
Inhospital Mortality				
Observed	1.77%	1.86%	1.78%	.055
Expected	1.77%	1.80%	1.81%	.185
10 Day Mortality after PCI				
Observed	1.77%	1.82%	1.80%	.57
Expected	1.77%	1.79%	1.81%	.08
30 Day Mortality after PCI				
Observed	2.51%	2.62%	2.51%	< .05
Expected	2.51%	2.57%	2.56%	.323
10 Day Mortality after Discharge				
Observed	0.45%	0.46%	0.44%	.405
Expected	0.45%	0.46%	0.45%	< .001

Table 7.7.A presents the base model (Eq. 7.1) estimates on the relation between patient mortality and instrumented multihospital practice ($\widetilde{MH}_{jt}$). Full models are presented in Appendix Tables A.7.5.1 through A.7.5.4. Unlike the patient injury models, physicians with a higher predicted probability of multihospital practice (e.g., quartile 4) are associated with a higher probability of inhospital mortality and mortality 10 and 30 days after PCI. As shown in Figure 7.3.A, moving from quartile 1 to quartile 4 of $\widetilde{MH}_{jt}$ increases the probability of inhospital mortality 13.7%, from 1.68% to 1.91%. Figure 7.3.A shows that going from quartile 1 to quartile 4 of $\widetilde{MH}_{jt}$ increases the probability of 30 day mortality after PCI 14.8% from 2.36% to 2.72%. Mortality 10 days after discharge does not appear to be related to $\widetilde{MH}_{jt}$. Figure 7.4.A shows the result for 30 day mortality after PCI.

Table 7.7.A—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Patient Mortality, Without Fixed Effects

VARIABLES	(1) Inhospital Death	(2) Death 10 Days from PCI	(3) Death 30 Days from PCI	(4) Death 10 Days from Discharge
Multihospital Physician ($\widetilde{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	0.000798	0.00105	0.00121	0.000237
	(0.000596)	(0.000562)	(0.000705)	(0.000241)
Quartile 3	0.00103	0.00149	0.00217*	0.000562
	(0.000938)	(0.000849)	(0.00110)	(0.000361)
Quartile 4	0.00228*	0.00274**	0.00354**	0.000551
	(0.00106)	(0.00101)	(0.00127)	(0.000381)
Physician Annual PCI Volume				
In the Patient's Hospital	-6.55e-06*	-6.84e-06*	-2.29e-06	7.61e-07
	(3.33e-06)	(3.06e-06)	(3.94e-06)	(1.41e-06)
In Other Hospitals	-3.79e-06	-2.50e-07	6.30e-06	4.86e-06
	(8.10e-06)	(7.97e-06)	(1.23e-05)	(4.59e-06)
Hospital Annual PCI Volume	-1.25e-07	-6.57e-07	1.73e-08	-7.31e-08
	(8.44e-07)	(8.65e-07)	(1.18e-06)	(3.27e-07)
Years as MD	-7.31e-05**	-5.99e-05**	-9.40e-05**	-1.69e-05
	(2.27e-05)	(2.18e-05)	(2.87e-05)	(9.65e-06)
Hospital Market Structure ($\widehat{HHI}_{jt}$)				
Category 1: 0 to 1250 (Ref)	--	--	--	--
Category 2: 1250 to 2500	0.00142	0.00158*	0.00158	-0.000119
	(0.000725)	(0.000700)	(0.000925)	(0.000265)
Category 3: 2500 to 5000	0.00140	0.00178*	0.00225*	0.000131
	(0.000913)	(0.000861)	(0.00115)	(0.000337)
Category 4: 5000 to 10000	0.00118	0.00252**	0.00201	0.000200
	(0.000941)	(0.000908)	(0.00121)	(0.000383)
Category 5: 0 PCI Hospitals in Market	-0.000761	0.00112	0.000887	0.00142*
	(0.00148)	(0.00141)	(0.00188)	(0.000697)
Observations	1,027,230	1,027,230	1,027,230	1,009,044
R2	0.045	0.037	0.049	0.007

Regression coefficients shown. Standard errors clustered at the physician market level.
*** $p<0.001$, ** $p<0.01$, * $p<0.05$

Physician volume in a patient's hospital is related as well: more volume in a patient's hospital lowers the probability of inhospital death. However, this volume effect is not related to 30 day mortality or post-discharge mortality. Years since medical school is significantly related to mortality: more tenured physicians are associated with lower inhospital and 30 day mortality rates.

Figure 7.3.A – Base Model Adjusted Inhospital Mortality by Instrumented Multihospital Practice Quartile

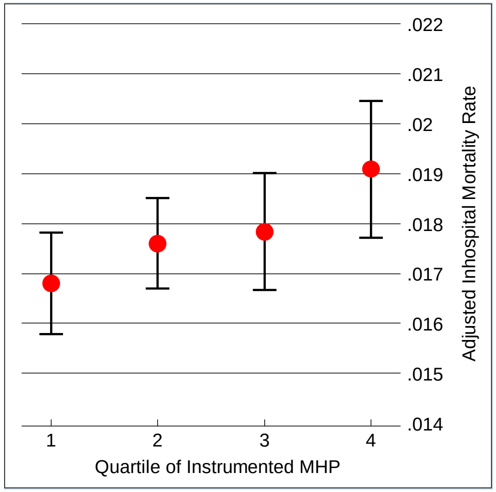


Figure 7.3.B – HRR Fixed Effect Model Adjusted Inhospital Mortality by Instrumented Multihospital Practice Quartile

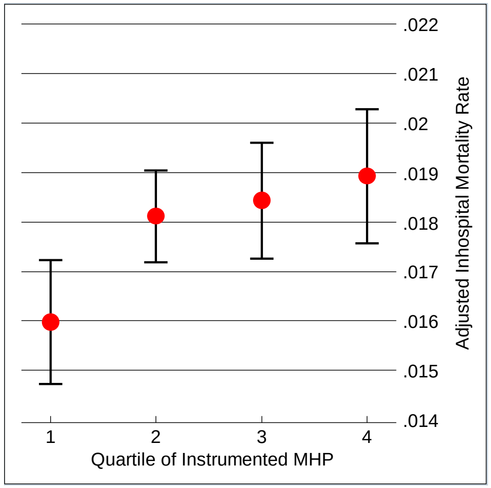


Figure 7.3.C – Hospital Fixed Effect Model Adjusted Inhospital Mortality by Instrumented Multihospital Practice Quartile

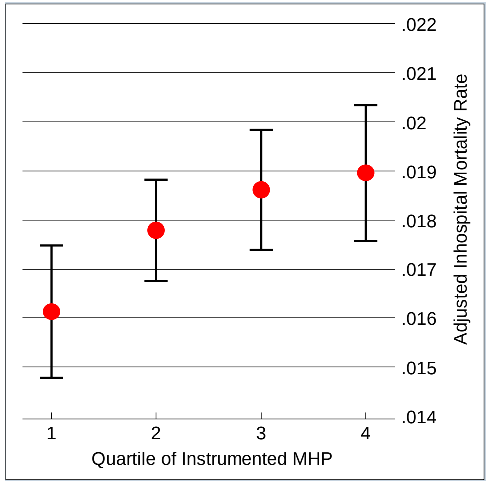


Figure 7.4.A – Base Model Adjusted 30 Day Mortality by Instrumented Multihospital Practice Quartile

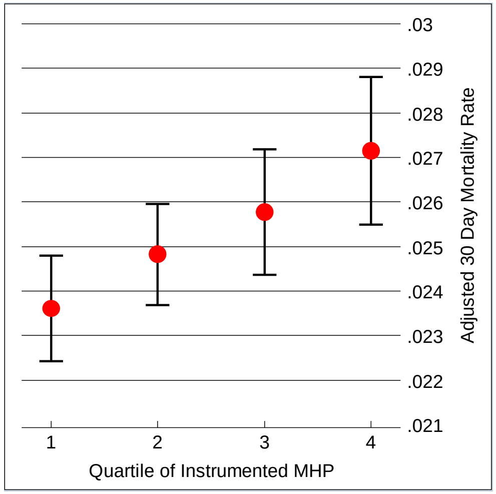


Figure 7.4.B – HRR Fixed Effect Model Adjusted 30 Day Mortality by Instrumented Multihospital Practice Quartile

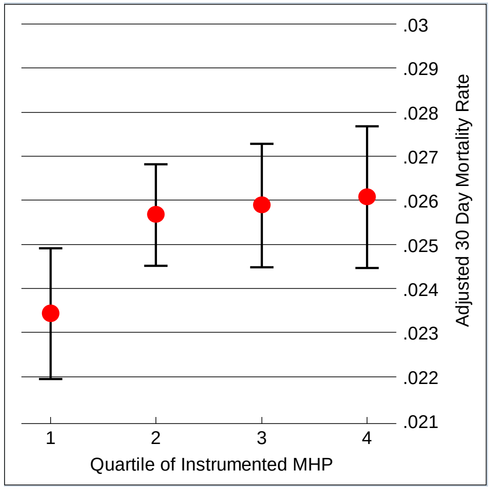


Figure 7.4.C – Hospital Fixed Effect Model Adjusted 30 Day Mortality by Instrumented Multihospital Practice Quartile

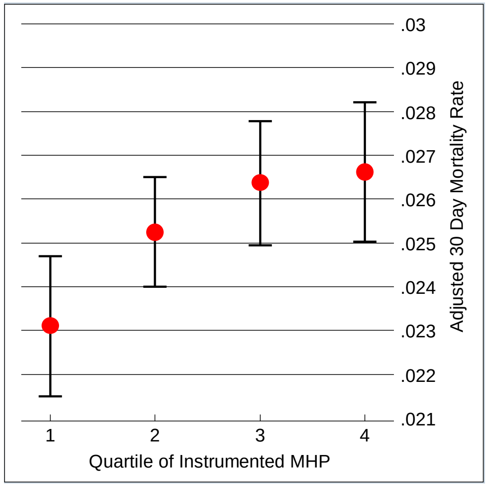


Table 7.7.B shows the estimates from the HRR fixed effect models of patient mortality. Full model results are presented in Appendix Tables A.7.6.1 through A.7.6.4. The results are consistent with the base model but there are several differences. The relation between 30 day mortality and instrumented multihospital practice has weakened to the point where quartile 4 is no longer significantly different than quartile 1. Quartile 2 and 3 remain significantly different, though. Conversely, the relation between instrumented multihospital practice and inhospital death has grown in size. As shown in Figure 7.3.B, moving from quartile 1 to quartile 4 of $\widehat{MH}_{jt}$ increases the probability of inhospital mortality from 1.59% to 1.89% (an increase of 18.8%).

Table 7.7.B—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Patient Mortality, With HRR Fixed Effects

VARIABLES	(1) Inhospital Death	(2) Death 10 Days from PCI	(3) Death 30 Days from PCI	(4) Death 10 Days from Discharge
Multihospital Physician ($\widetilde{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	0.00212**	0.00201**	0.00224*	6.30e-05
	(0.000765)	(0.000751)	(0.000945)	(0.000416)
Quartile 3	0.00245*	0.00230*	0.00245*	0.000180
	(0.00106)	(0.00104)	(0.00122)	(0.000584)
Quartile 4	0.00294*	0.00270*	0.00264	-0.000158
	(0.00117)	(0.00114)	(0.00135)	(0.000596)
Physician Annual PCI Volume				
In the Patient's Hospital	-1.16e-06	-9.74e-07	3.99e-06	1.90e-06
	(4.07e-06)	(3.67e-06)	(4.60e-06)	(1.50e-06)
In Other Hospitals	4.13e-07	3.03e-06	1.32e-05	6.26e-06
	(8.89e-06)	(8.17e-06)	(1.18e-05)	(4.18e-06)
Hospital Annual PCI Volume	5.36e-07	-1.42e-07	8.24e-07	-2.84e-07
	(9.17e-07)	(8.67e-07)	(1.11e-06)	(3.79e-07)
Years as MD	-8.67e-05***	-8.01e-05***	-0.000121***	-2.08e-05*
	(2.18e-05)	(2.09e-05)	(2.70e-05)	(1.04e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)				
Category 1: 0 to 1250 (Ref)	--		--	--
Category 2: 1250 to 2500	0.000277	0.000475	-0.000269	-0.00116*
	(0.000927)	(0.000906)	(0.00116)	(0.000462)
Category 3: 2500 to 5000	0.00130	0.00152	0.000826	-0.000811
	(0.00122)	(0.00119)	(0.00145)	(0.000641)
Category 4: 5000 to 10000	0.000933	0.00186	0.000331	-0.000770
	(0.00135)	(0.00132)	(0.00157)	(0.000687)
Category 5: 0 PCI Hospitals in Market	-0.000721	0.000601	-0.00100	0.000258
	(0.00178)	(0.00178)	(0.00227)	(0.000947)
Observations	1,027,230	1,027,230	1,027,230	1,009,044
R2	0.044	0.037	0.048	0.007
Number of Fixed Effects	305	305	305	305

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

The hospital fixed effect model estimates are shown in Table 7.7.C. Appendix tables A.7.7.1 through A.7.7.4 present the full models. The results are consistent with the HRR fixed effect model and the base model without fixed effects. Both inhospital mortality and 30 day mortality hold a significant relation with instrumented multihospital practice. As shown in Figure 7.3.C, moving from quartile 1 to quartile 4 of $\widetilde{MH}_{jt}$

increases the probability of inhospital mortality from 1.61% to 1.89% (an increase of 17.3%). In Figure 7.4.C, moving from quartile 1 to quartile 4 of $\widetilde{MH}_{jt}$ increases the probability of 30 day mortality from 2.31% to 2.66% (an increase of 15.1%). Just like the HRR fixed effect model, annual PCI volumes (physician or hospital) do not hold a relation with mortality, but years since medical graduation does hold a significant relation with mortality: more tenured physicians have lower inhospital and 30 day mortality rates.

Table 7.7.C—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Patient Mortality, With Hospital Fixed Effects

VARIABLES	(1) Inhospital Death	(2) Death 10 Days from PCI	(3) Death 30 Days from PCI	(4) Death 10 Days from Discharge
Multihospital Physician ($\widetilde{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	0.00166	0.00171	0.00215*	0.000191
	(0.000884)	(0.000873)	(0.00107)	(0.000437)
Quartile 3	0.00248*	0.00228*	0.00327**	0.000515
	(0.00110)	(0.00110)	(0.00127)	(0.000553)
Quartile 4	0.00282*	0.00281*	0.00351**	0.000392
	(0.00119)	(0.00117)	(0.00135)	(0.000613)
Physician Annual PCI Volume				
In the Patient’s Hospital	-2.03e-06	2.86e-07	2.59e-06	2.04e-06
	(4.48e-06)	(3.81e-06)	(4.90e-06)	(1.62e-06)
In Other Hospitals	2.26e-06	4.78e-06	1.15e-05	5.79e-06
	(8.71e-06)	(8.40e-06)	(1.13e-05)	(4.80e-06)
Hospital Annual PCI Volume	3.42e-06	2.96e-06	5.05e-06	-1.01e-07
	(2.05e-06)	(2.04e-06)	(2.75e-06)	(1.32e-06)
Years as MD	-0.000104***	-9.08e-05***	-0.000131***	-1.73e-05
	(2.18e-05)	(2.08e-05)	(2.70e-05)	(1.06e-05)
Observations	1,027,230	1,027,230	1,027,230	1,009,044
R2	0.043	0.036	0.047	0.006
Number of Fixed Effects	1,276	1,276	1,276	1,276

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

As was the case with the injury models, the base models (those without fixed effects) are overidentified. Table 7.8 contains the F-test and p value estimates for Eq. 7.2, which is a regression of , u_{ijht} on my set of instruments, Z_{jt}. The fixed effect models (both the HRR and hospital) fail to reject the hypothesis that at least 1 of my instruments are invalid, indicating that overidentification is controlled for after incorporating the fixed effect for region (hospitals nest within regions).

Table 7.8 – Mortality Model F-tests for Overidentification

VARIABLES	(1) Inhospital Death	(2) Death 10 Days from PCI	(3) Death 30 Days from PCI	(4) Death 10 Days from Discharge
Base Model (without FEs)				
F-test	2.04*	2.05*	2.38*	1.28
p	0.0381	0.0375	0.0145	0.2482
HRR Fixed Effects				
F-test	0.28	0.25	0.12	0.68
p	0.9729	0.981	0.9986	0.7119
Hospital Fixed Effects				
F-test	0.52	0.24	0.18	0.97
p	0.8459	0.983	0.9936	0.4560

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

Comparison to Endogenous Models

Using an indicator for multihospital practice (MH_{jt}) equal to 1 if physician j worked in multiple hospitals during year t, and observed hospital market structure (HHI_{jt}), I estimated the "uncorrected" versions of the HRR fixed effect mortality models (the endogenous version of Eq. 7.7) and the hospital fixed effect mortality models (the endogenous version of Eq. 7.8). Tables 7.9.A and 7.9.B contain the estimates from these models.

Unlike the "corrected" versions with instrumented $\widehat{MH}_{jt}$, uncorrected multihospital practice holds no relation with my set of mortality outcomes. This suggests there is favorable selection into multihospital practices that biases uncorrected results toward finding no detrimental effect. However, visually comparing the adjusted mortality rates between the uncorrected and corrected measures of multihospital practice suggests that the bias is really unfavorable selection into solo-hospital practices. Unobserved factors appear to be making solo-hospital performance worse than it actually is. This corresponds with the observed descriptive characteristics above (in Table 7.1.A), which showed that multihospital physicians do fewer primary PCI (a.k.a., emergent heart attacks) and more elective PCI. Figures 7.5.A through 7.5.D show the HRR fixed effect model comparison between uncorrected and corrected multihospital practice, and Figures 7.6.A through 7.6.D show the hospital fixed effect model comparison.

Table 7.9.A—Relation between Patient Mortality and Uncorrected Multihospital Practice Quartile (MH_{jt}) and Hospital Market Structure (HHI_{jt}), With HRR Fixed Effects

VARIABLES	(1) Inhospital Death	(2) Death 10 Days from PCI	(3) Death 30 Days from PCI	(4) Death 10 Days from Discharge
Multihospital Physician (MH_{jt})	0.000269	0.000264	0.000631	0.000275
	(0.000405)	(0.000398)	(0.000473)	(0.000181)
Physician Annual PCI Volume				
In the Patient's Hospital	-1.57e-06	-1.15e-06	3.68e-06	1.94e-06
	(4.08e-06)	(3.80e-06)	(4.69e-06)	(1.56e-06)
In Other Hospitals	-8.15e-07	1.68e-06	9.60e-06	4.59e-06
	(9.00e-06)	(8.11e-06)	(1.09e-05)	(4.25e-06)
Hospital Annual PCI Volume	6.31e-07	-7.51e-08	9.11e-07	-2.52e-07
	(1.01e-06)	(1.02e-06)	(1.23e-06)	(3.69e-07)
Years as MD	-8.53e-05***	-7.92e-05***	-0.000119***	-2.03e-05*
	(2.36e-05)	(2.34e-05)	(2.74e-05)	(9.20e-06)
Hospital Market Structure (HHI_{jt})				
Category 1: 0 to 1250 (Ref)	--		--	--
Category 2: 1250 to 2500	-3.68e-05	-0.000196	-0.000771	-0.000570
	(0.000854)	(0.00102)	(0.00103)	(0.000415)
Category 3: 2500 to 5000	0.000247	0.000118	-0.000280	-0.000698
	(0.000954)	(0.00110)	(0.00116)	(0.000468)
Category 4: 5000 to 10000	-0.00120	-0.000683	-0.00200	-0.000598
	(0.00111)	(0.00122)	(0.00132)	(0.000458)
Category 5: 0 PCI Hospitals in Market	-0.00336*	-0.00224	-0.00380*	0.000373
	(0.00146)	(0.00147)	(0.00185)	(0.000676)
Observations	1,027,230	1,027,230	1,027,230	1,009,044
R2	0.044	0.037	0.048	0.007
Number of Fixed Effects	305	305	305	305

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table 7.9.B—Relation between Patient Mortality and Uncorrected Multihospital Practice Quartile (MH_{jt}) and Hospital Market Structure (HHI_{jt}), With Hospital Fixed Effects

VARIABLES	(1) Inhospital Death	(2) Death 10 Days from PCI	(3) Death 30 Days from PCI	(4) Death 10 Days from Discharge
Multihospital Physician (MH_{jt})	-3.05e-05	5.63e-05	0.000271	0.000294
	(0.000381)	(0.000382)	(0.000452)	(0.000190)
Physician Annual PCI Volume				
In the Patient's Hospital	-2.08e-06	2.46e-07	2.56e-06	2.05e-06
	(4.19e-06)	(3.57e-06)	(4.81e-06)	(1.77e-06)
In Other Hospitals	2.15e-06	4.24e-06	9.59e-06	4.03e-06
	(8.34e-06)	(8.39e-06)	(9.73e-06)	(4.09e-06)
Hospital Annual PCI Volume	3.37e-06	2.97e-06	5.01e-06	-9.59e-08
	(2.01e-06)	(2.18e-06)	(2.73e-06)	(1.43e-06)
Years as MD	-0.000104***	-8.99e-05***	-0.000129***	-1.64e-05
	(2.30e-05)	(2.12e-05)	(2.63e-05)	(1.03e-05)
Observations	1,027,230	1,027,230	1,027,230	1,009,044
R2	0.043	0.036	0.047	0.006
Number of Fixed Effects	1,276	1,276	1,276	1,276

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Figure 7.5.A – HRR Fixed Effect Model Adjusted Inhospital Mortality by Uncorrected Multihospital Practice Indicator

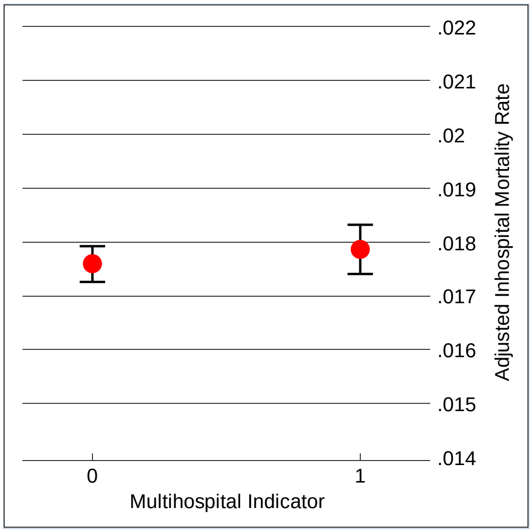


Figure 7.5.B – HRR Fixed Effect Model Adjusted Inhospital Mortality by Corrected Multihospital Practice Indicator

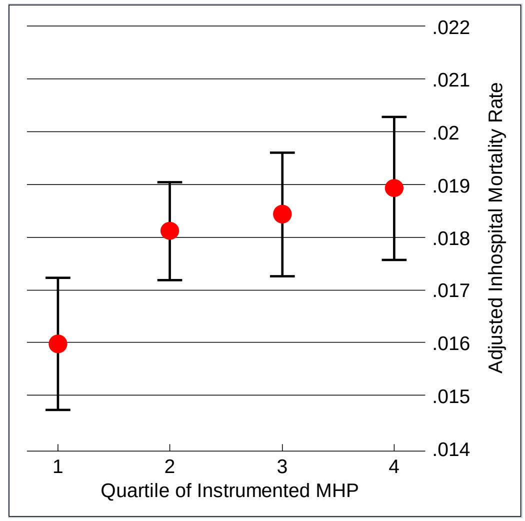


Figure 7.5.C – HRR Fixed Effect Model Adjusted 30 Day Mortality by Uncorrected Multihospital Practice Indicator

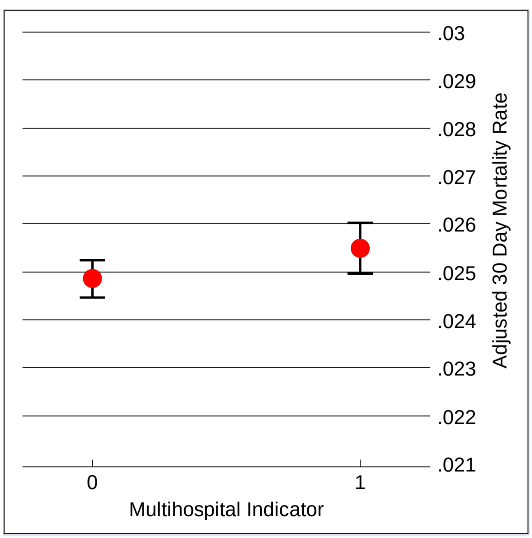


Figure 7.5.D – HRR Fixed Effect Model Adjusted 30 Day Mortality by Corrected Multihospital Practice Indicator

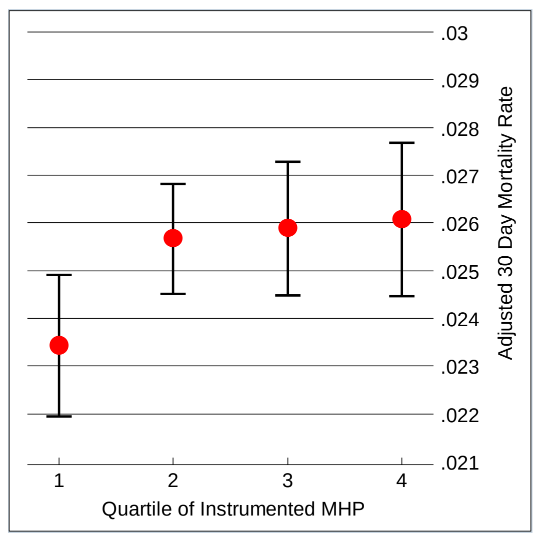


Figure 7.6.A – Hospital Fixed Effect Model Adjusted Inhospital Mortality by Uncorrected Multihospital Practice Indicator

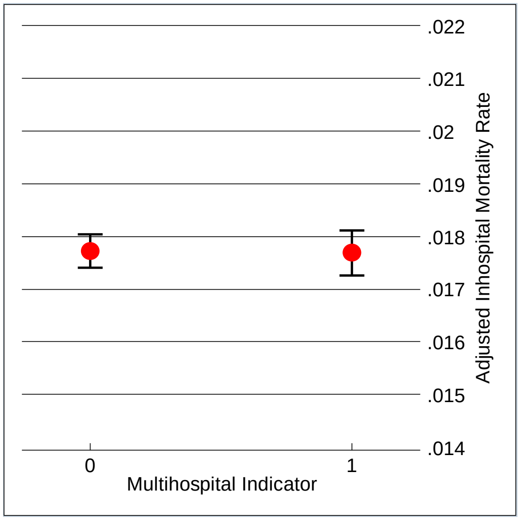


Figure 7.6.B – Hospital Fixed Effect Model Adjusted Inhospital Mortality by Corrected Multihospital Practice Indicator

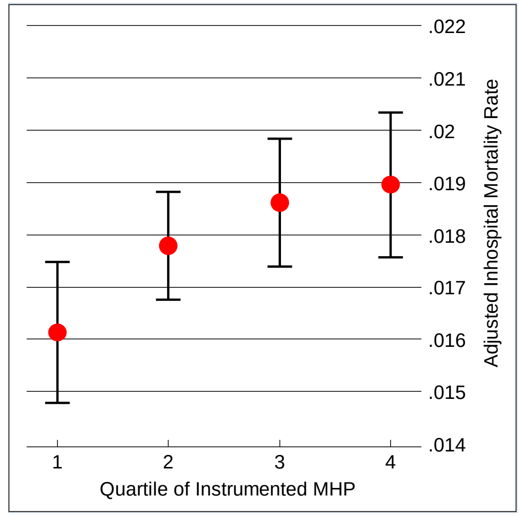


Figure 7.6.C – Hospital Fixed Effect Model Adjusted 30 Day Mortality by Uncorrected Multihospital Practice Indicator

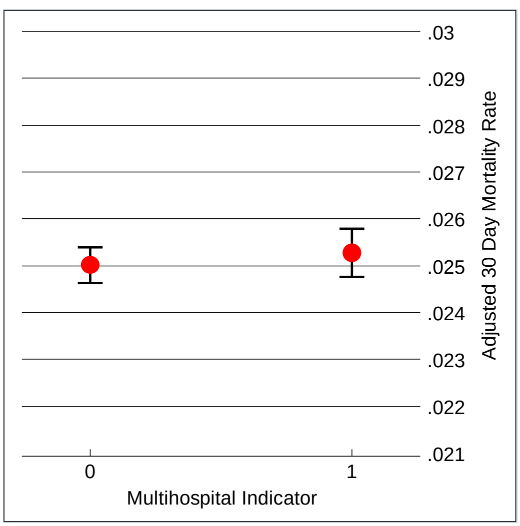
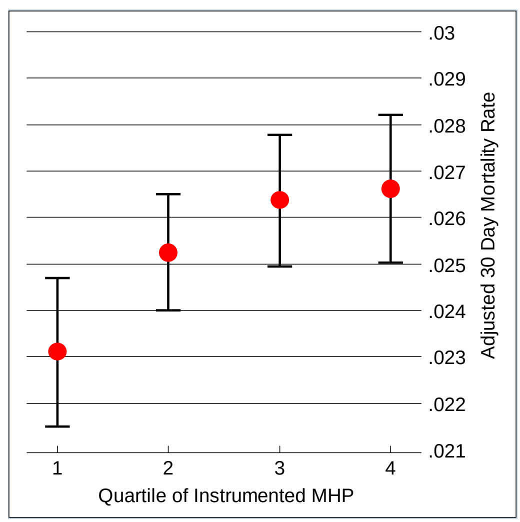


Figure 7.6.D – Hospital Fixed Effect Model Adjusted 30 Day Mortality by Corrected Multihospital Practice Indicator



Chapter 8: Additional Analyses

My conceptual model is multihospital practice creates more physician-hospital teams with less shared experienced (i.e. volume), and more limited physician availability before and after a procedure. Both of these factors are believed to create more medical error, which can lead to adverse patient outcomes like injury and death.

In chapter 7, I showed that patient injury is related to physician experience. More PCI volume in a patient's hospital was associated with a lower risk of injury from medical error. However, patient injury did not also depend on whether the physician was multihospital or not. Unless a physician's PCI volume is affected by multihospital practice, there appears to be no additional difference in patient injury risk between solo-hospital physicians and multihospital physicians. In my patient mortality models, I found the opposite result: physician experience was not related to mortality, but multihospital practice was associated with higher inhospital and 30 day mortality.

There are several features of these results that deserve more explanation. First, volume has a well-known relation with patient mortality (indeed, I show it has a relation with less patient injury), why is volume unrelated to patient mortality? Second, what explains the relation between multihospital practice and mortality if experience is unrelated? This chapter offers some evidence to better explain both issues.

Why is physician PCI volume related to patient injury, but not patient mortality?

In Table 7.4.C, I showed that higher physician volume is negatively associated with patient injury from medical errors. However, in Tables 7.7.C I showed that physician volume was not significantly related to patient mortality. To better understand Table 7.7.C, I estimated the inpatient and 30 day mortality models in 4 steps. I started by estimating just the relation between instrumented multihospital practice $\widehat{MH}_{jt}$ and inhospital mortality (all models have hospital fixed effects and year dummies), then I sequentially added volume characteristics, patient characteristics, and physician characteristics to the model (which was the full model shown in Table 7.7.C). Table 8.1.A and Table 8.1.B report the estimated coefficients after each set of characteristics was added to the inhospital mortality model and 30 day mortality model respectively.

Table 8.1.A—Inhospital Mortality Model with Hospital Fixed Effects: Estimate Changes after Sequentially Adding Volume Characteristics, Patient Characteristics, then Physician Characteristics

VARIABLES	(1) Corrected $\widehat{MH}_{jt}$ Only	(2) Add Annual PCI Volumes	(3) Add Patient Characteristics	(4) Add Physician Characteristics
Multihospital Physician ($\widehat{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	0.00328***	0.00327***	0.00164*	0.00166*
	(0.000795)	(0.000808)	(0.000692)	(0.000690)
Quartile 3	0.00389***	0.00388***	0.00245**	0.00248**
	(0.000924)	(0.000942)	(0.000888)	(0.000883)
Quartile 4	0.00468***	0.00481***	0.00279**	0.00282**
	(0.000997)	(0.00101)	(0.000911)	(0.000905)
Physician Annual PCI Volume				
In the Patient's Hospital		-3.46e-05***	-3.43e-06	-2.03e-06
		(4.39e-06)	(4.10e-06)	(4.21e-06)
In Other Hospitals		-6.51e-07	2.87e-06	2.26e-06
		(8.41e-06)	(8.15e-06)	(8.04e-06)
Hospital Annual PCI Volume		-7.48e-06***	3.67e-06	3.42e-06
		(2.13e-06)	(2.02e-06)	(2.01e-06)
Years as MD				-0.000104***
				(2.30e-05)
Observations	1,027,230	1,027,230	1,027,230	1,027,230
R2	0.000	0.000	0.043	0.043
Number of Fixed Effects	1,276	1,276	1,276	1,276

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

I find that physician volume holds a significant relation with unadjusted patient mortality. However, the significance goes away after adjusting for differences in patient severity. This suggests that high volume physicians see relatively healthier patients. One possibility (that fits the findings from chapter 7) is patient injury differences from medical error are not (primarily) based on patient severity. Instead, injuries from medical errors like puncture are based on provider differences like procedure experience or physician ability. Mortality, on the other hand, is primarily based on the severity of the patient, and higher volume physicians deliver relatively more PCI to healthier patients. After accounting for patient severity, the mortality relation goes away while the injury relation remains.

Another possibility is that the volume-injury relation is too small to really make a difference in explaining differences in mortality. The volume-injury relation I found in Table 7.4.C was quite small in magnitude. The estimated coefficient on the physician's volume in a patient's hospital was -0.0000158. This means that each additional PCI a physician delivered in a patient's hospital would lower the probability of injury by that amount. If a physician went from the 5th percentile of physician-hospital-year volume (taken at the physician-hospital-year level) to the 95th percentile, they would increase their volume in a patient's hospital from 1 PCI to 83 PCI a year. Assuming this happened (which would be a massive increase in physician volume), and using the estimates from Table 7.4.C., the probability of patient injury from medical error would fall 8%, from 1.62% to 1.49%.

While this is an important finding, it's unclear what influence lower injury rates would ultimately have on patient mortality. To explore this possibility, I added my variable for patient injury from medical error ($Likely\ Error_{ijht}$) to my inpatient mortality model with hospital fixed effects (Eq. 7.8) and estimated its effect on inpatient mortality. I found that an injury from a medical error increased the probability of inhospital death by over 0.052 (95% CI, 0.047 to 0.0568), or 5.2 percentage points. The adjusted inhospital death rate without an injury was 1.69%, and with an injury it was 6.89%. This is a huge effect, an increase of 307%. But, that is the effect if we observe an injury from error with certainty. Instead, if the probability of an error moved from 1.62% to 1.49%, like it would going from the 5^{th} to 95^{th} percentile of physician-hospital-year volume, then the effect of injury on mortality would go from 0.000842 to 0.000775, a difference of 0.0000676 or 0.00676 percentage points. In other words, the influence of higher volume would change mortality very little if it only influenced mortality through patient injuries from medical error.

Table 8.1.B—30 Day Mortality after PCI Model with Hospital Fixed Effects: Estimate Changes after Sequentially Adding Volume Characteristics, Patient Characteristics, then Physician Characteristics

VARIABLES	(1) Corrected $\widehat{MH}_{jt}$ Only	(2) Add Annual PCI Volumes	(3) Add Patient Characteristics	(4) Add Physician Characteristics
Multihospital Physician ($\widehat{MH}_{jt}$)				
Quartile 1 (Ref)	--	--	--	--
Quartile 2	0.00400***	0.00396***	0.00211*	0.00215**
	(0.000929)	(0.000935)	(0.000820)	(0.000820)
Quartile 3	0.00487***	0.00489***	0.00319**	0.00327**
	(0.00112)	(0.00114)	(0.00108)	(0.00108)
Quartile 4	0.00565***	0.00579***	0.00343**	0.00351**
	(0.00123)	(0.00123)	(0.00115)	(0.00114)
Physician Annual PCI Volume				
In the Patient's Hospital		-3.47e-05***	7.14e-07	2.59e-06
		(5.91e-06)	(4.78e-06)	(4.84e-06)
In Other Hospitals		1.28e-05	1.24e-05	1.15e-05
		(1.01e-05)	(9.49e-06)	(9.36e-06)
Hospital Annual PCI Volume		-6.46e-06*	5.39e-06*	5.05e-06
		(2.90e-06)	(2.72e-06)	(2.71e-06)
Years as MD				-0.000131***
				(2.63e-05)
Observations	1,027,230	1,027,230	1,027,230	1,027,230
R2	0.000	0.000	0.047	0.047
Number of Fixed Effects	1,276	1,276	1,276	1,276

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Why is multihospital practice related to patient mortality after PCI?

If physician-hospital experience is not the mechanism through which multihospital practice affects mortality, then what explains the significant relations identified in chapter 7?

In the hospital fixed effect mortality models (Eq. 7.8), I controlled for hospital differences through the fixed effect, and patient severity appeared to be balanced. There are two remaining possibilities that could explain the relation with multihospital practice. First, mortality differences could be explained by unobserved differences in physician quality or ability that do not manifest themselves in patient injury. Greater mutual investments between hospitals and their solo-hospital physicians could create a quality differential with multihospital physicians, whose loyalties are divided across multiple hospitals. However, this is highly unlikely as a quality differential would generate patient injury differences, which it doesn't.

The other possibility is that multihospital practice creates greater patient severity (and therefore, creates greater mortality risk) for patients, and it does so in a way that's not captured by observable patient characteristics. For PCI, the mechanism for how this occurs is through the availability of the physician before a patient's PCI.

If a physician is not in a patient's hospital when the patient shows up (i.e., they're not available before the PCI), then the hospital will need to call the physician to the hospital to deliver the procedure. This creates additional risk when the patient's condition is sensitive to the time-to-PCI (a.k.a., time-to balloon), as would be the case for primary PCI delivered to heart attack patients. More heart damage occurs the longer a patient's coronary artery is occluded. Therefore, if calling a physician to a hospital increases the time-to-balloon, this could result in additional mortality risk for patients—even after controlling for their observed characteristics. Multihospital physicians that have a "primary" hospital (i.e., where they do most of their work) and "secondary" hospitals (i.e., other hospitals they work in less often) are more likely to be called-in to their secondary hospitals and will be more likely to create longer times-to-balloon for their emergent PCI patients in secondary hospitals. This could explain the relation between higher patient mortality and multihospital practice that would not necessarily be a function of physician experience in a patient's hospital or a function of patient injuries from medical error.

The availability of the physician after a PCI could also matter. If a physician shows up to deliver a PCI and then transfers the patient's care to other physicians and hospital staff or directs it remotely, then the patient may be more likely to have post-acute care complication due to information being dropped in the transitions. Patients may also be more disconnected from their PCI physician and unsure about who to contact about complications, leading to more adverse outcomes like mortality. Again, this will be more likely for emergent PCI delivered by multihospital physicians in secondary hospitals, where the patient's physician is not primarily located, and could explain the relation between multihospital practice and higher 30 day mortality without involving patient injury or physician experience in a hospital.

To explore these possibility more closely, I tried several additional models. First, I split my sample into 2 subpopulations based on whether a patient would have selected their PCI physician. I did this using the admission source of the patient. If the patient was an outpatient, or if they were a physician referral (i.e., admitted by the physician), then I classified the patient as "selected physician". If a patient was admitted via the emergency department, or if they were admitted via a transfer into the hospital (i.e., they were transferred in from another institutional setting), then I classified the patient as "did not select physician". Using separate models, I estimated the relation between instrumented multihospital practice and patient mortality using the hospital fixed effect model (Eq. 7.8).

Tables 8.2.A and 8.2.B contain the estimates for inhospital mortality and 30 day mortality respectively. Appendix tables A.8.1.1 through A.8.2.2 present the full models. Multihospital practice does not appear to related to mortality for patients that (probably) selected their PCI physician. For ED and transfer patients—who (probably) did not select their PCI physician or PCI hospital—multihospital practice is significantly related to inhospital and 30 day mortality.

Table 8.2.A—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inhospital Mortality for Patients that Selected their Physician and for Patients that Did Not

VARIABLES	All Patients	Patient Subpopulations: Outpatient or Referral "Selected Physician"	Patient Subpopulations: ED or Transfer "Did Not Select Physician"
Multihospital Physician ($\widetilde{MH}_{jt}$)			
Quartile 1 (Ref)	--	--	--
Quartile 2	0.00166	0.000405	0.00403*
	(0.000884)	(0.000772)	(0.00193)
Quartile 3	0.00248*	0.00147	0.00502*
	(0.00110)	(0.000912)	(0.00219)
Quartile 4	0.00282*	0.00117	0.00536*
	(0.00119)	(0.00103)	(0.00245)
Physician Annual PCI Volume			
In the Patient's Hospital	-2.03e-06	-2.98e-06	-1.08e-06
	(4.48e-06)	(3.93e-06)	(8.91e-06)
In Other Hospitals	2.26e-06	4.16e-06	-1.05e-06
	(8.71e-06)	(8.55e-06)	(1.78e-05)
Hospital Annual PCI Volume	3.42e-06	3.27e-06*	4.40e-06
	(2.05e-06)	(1.60e-06)	(4.50e-06)
Years as MD	-0.000104***	-6.45e-05**	-0.000130**
	(2.18e-05)	(2.01e-05)	(4.57e-05)
Observations	1,027,230	611,286	415,944
R2	0.043	0.033	0.044
Number of Fixed Effects	1,276	1,271	1,271

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table 8.2.B—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and 30 Day Mortality for Patients that Selected their Physician and for Patients that Did Not

VARIABLES	All Patients	Patient Subpopulations: Outpatient or Referral "Selected Physician"	Patient Subpopulations: ED or Transfer "Did Not Select Physician"
Multihospital Physician ($\widetilde{MH}_{jt}$)			
Quartile 1 (Ref)	--	--	--
Quartile 2	0.00215*	0.000582	0.00457*
	(0.00107)	(0.00108)	(0.00214)
Quartile 3	0.00327**	0.00166	0.00636*
	(0.00127)	(0.00117)	(0.00248)
Quartile 4	0.00351**	0.00135	0.00587*
	(0.00135)	(0.00130)	(0.00275)
Physician Annual PCI Volume			
In the Patient's Hospital	2.59e-06	-6.00e-07	9.89e-06
	(4.90e-06)	(3.74e-06)	(1.05e-05)
In Other Hospitals	1.15e-05	4.13e-06	2.40e-05
	(1.13e-05)	(1.02e-05)	(2.14e-05)
Hospital Annual PCI Volume	5.05e-06	5.46e-06*	4.49e-06
	(2.75e-06)	(2.23e-06)	(5.45e-06)
Years as MD	-0.000131***	-8.86e-05***	-0.000162**
	(2.70e-05)	(2.34e-05)	(5.11e-05)
Observations	1,027,230	611,286	415,944
R2	0.047	0.035	0.047
Number of Fixed Effects	1,276	1,271	1,271

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Figures 8.1.A through 8.1.D show the adjusted mortality rates by multihospital quartile for each subpopulation model in Table 8.2. It's clear that the separation between quartile 1 and quartile 4 mortality (inhospital and 30 day) is driven by differences in the ED and transfer patient subpopulation. These are the patients that would have been affected by the availability of the physician before their PCI, where their physician may have been in another hospital (or at home) and was called-in to deliver their PCI.

Figure 8.1.A – Outpatient & Referral Patients Only, Adjusted Inhospital Mortality by Corrected Multihospital Practice Quartile

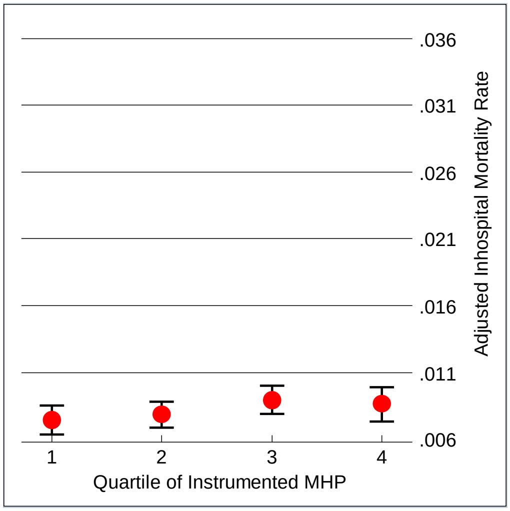


Figure 8.1.B – ED & Transfer Patients Only, Adjusted Inhospital Mortality by Corrected Multihospital Practice Quartile

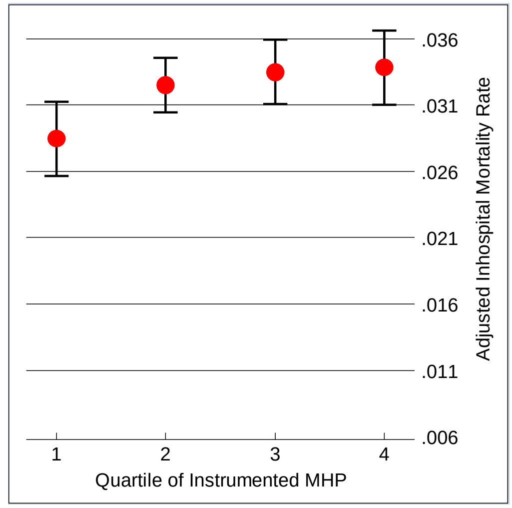


Figure 8.1.C – Outpatient & Referral Patients Only, Adjusted 30 Day Mortality by Corrected Multihospital Practice Quartile

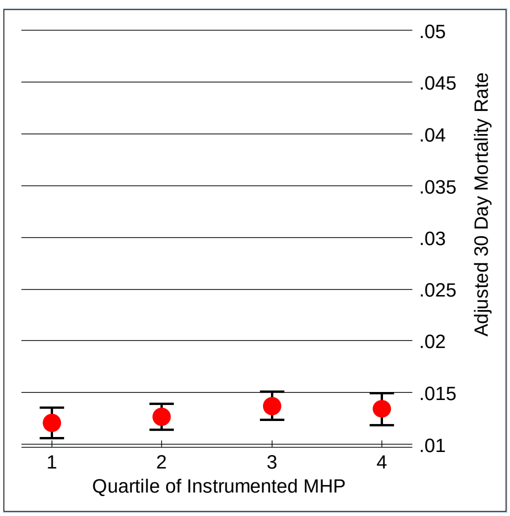
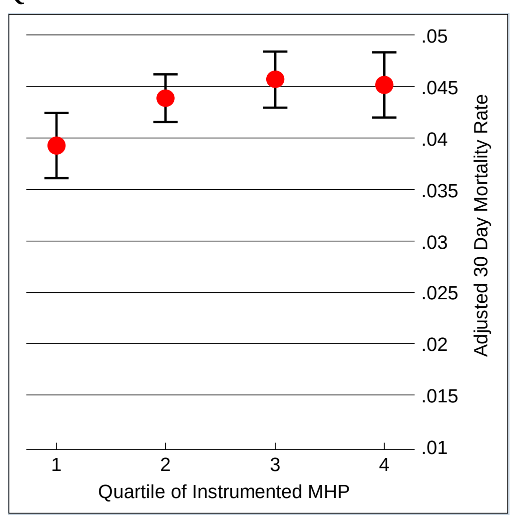


Figure 8.1.D – ED & Transfer Patients Only, Adjusted 30 Day Mortality by Corrected Multihospital Practice Quartile



To explore this possibility more, I identified days in which multihospital physicians worked in more than 1 hospital. To do this, I used the uncorrected measure of multihospital practice (MH_{jt}) and looked for days in which the physician billed PCI from 2 different hospitals and created a variable ($sameday\ MH_{ij}$) that was equal to 1 for PCI delivered on a day the physician worked in more than 1 hospital. Using MH_{jt} and $sameday\ MH_{ij}$, I created a categorical variable that classified physicians into 3 groups based on their multihospital status and if they worked in more than 1 hospital on the day of their patient's PCI. These were: (a) solo-hospital physicians (who always work in 1 hospital per day), (b) multihospital physicians on days they worked in 1 hospital, and (c) multihospital physicians on days they worked in more than 1 hospital.

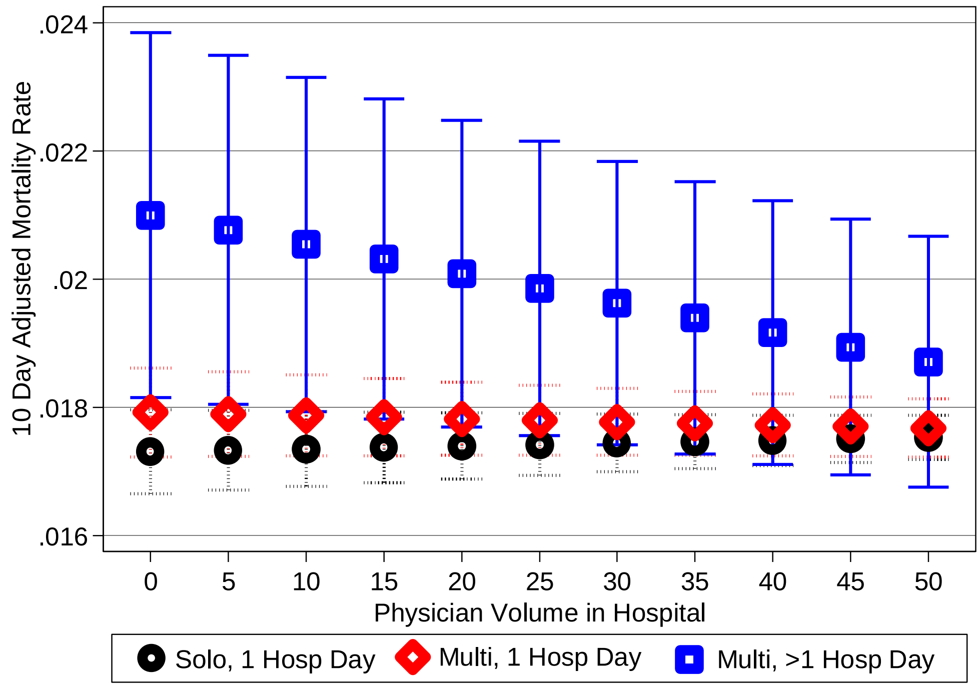
Then, I modeled whether 10 day mortality ($10\ Days\ after\ PCI_{ijht}$) after PCI was related to differences between these 3 groups interacted with a physician's experience in a patient's hospital. I used the hospital fixed effect model (Eq. 7.8) for this model. Table 8.3 contains the estimates from this model, and Figure 8.2 presents the result visually. Appendix table A.8.3 presents the full model result.

Table 8.3—Relation between 10 Day Mortality after PCI and Physician Group—Uncorrected Multihospital Status (MH_{jt}) and More than 1 Hospital Days ($sameday\ MH_{ij}$)—Interacted with the Physician's PCI Volume in the Hospital

VARIABLES	Coef.	SE
Physician Group		
Solo-Hospital Physician (ref)	--	--
Multihospital Physician in 1 Hospital that Day	0.000612	(0.000505)
Multihospital Physician in More than 1 Hospital that Day	0.00369*	(0.00150)
Physician Annual PCI Volume		
In the Patient's Hospital	4.45e-06	(4.37e-06)
In Other Hospitals	1.79e-06	(8.05e-06)
Hospital Annual PCI Volume	2.94e-06	(2.17e-06)
Years as MD	-9.08e-05***	(2.11e-05)
Interaction between Physician Annual PCI Volume In the Patient's Hospital and		
Solo-Hospital Physician (ref)	--	--
Multihospital Physician in 1 Hospital that Day	-9.30e-06	(5.15e-06)
Multihospital Physician in More than 1 Hospital that Day	-5.02e-05**	(1.71e-05)
Observations	1,027,230	
R2	0.036	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Figure 8.2—10 Day Mortality after PCI for Solo-Hospital Physicians in 1 Hospital that Day, Multihospital Physicians in 1 Hospital that Day, and Multihospital Physicians in >1 Hospital that Day, by Annual Physician Volume in that Hospital



There is no significant difference between multihospital physicians and solo-hospital physicians on days they work in only 1 hospital. Moreover, physician experience in a hospital does not appear to matter on 1 hospital days: not for solo-hospital physicians or multihospital physicians. However, there is a significant difference between solo-hospital physicians and multihospital physicians on days the multihospital physician works in multiple hospitals. In addition, experience in the patient's hospital matters: the added risk to patients from multihospital days decays as the physician's experience in the hospital grows. This suggests that the difference in mortality risk adversely affects patients in secondary hospitals.

To explore this possibility more, I estimated an additional model the used just the PCIs delivered by multihospital physicians. For this model, I identified the physician's primary hospital as the one they used the most in year t (i.e., the plurality of their PCI volume was delivered in the hospital), and their secondary hospitals as the other hospitals they worked in. I created a variable ($secondary_{ijht}$) equal to 1 if patient i's hospital h was a secondary hospital for physician j in year t. Then, I included $sameday\ MH_{ij}$, $secondary_{ijht}$ and an interaction between the two variables in my hospital fixed effect model. Table 8.4 contains the estimates from this regression, and Figure 8.3 displays the result. Appendix table A.8.4 presents the full model result.

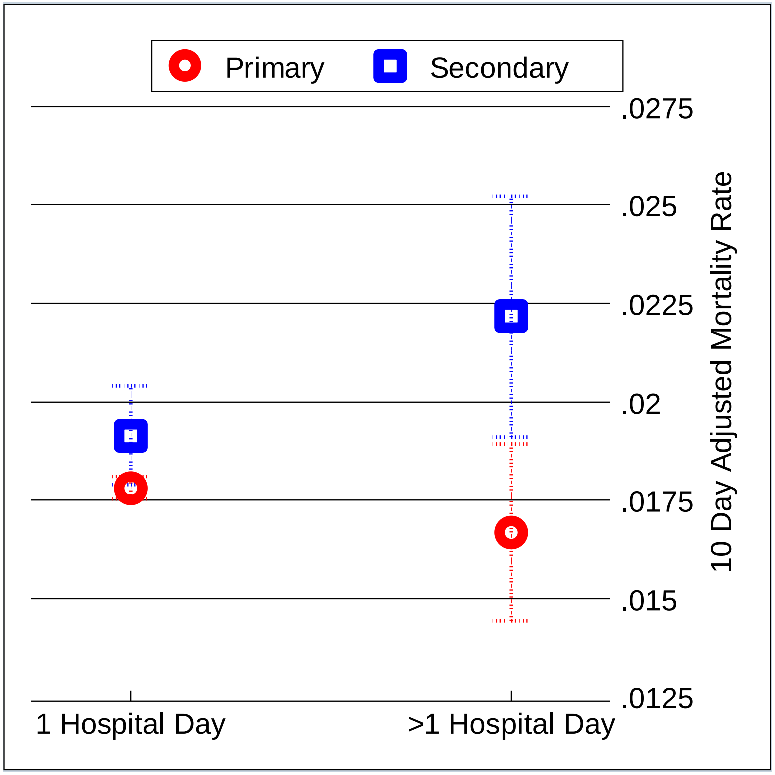
Table 8.4—Relation between 10 Day Mortality after PCI and Same-Day Multihospital Practice in the Physician's Secondary Hospitals Compared to their Primary Hospital

VARIABLES	Coef.	SE
Same-Day Multihospital	-0.00112	(0.00118)
Hospital Status		
Primary (ref)		
Secondary	0.00132	(0.000777)
Interaction between Same-Day Multihospital and Secondary Hospital Status	0.00415*	(0.00199)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.53e-06	(4.97e-06)
In Other Hospitals	-6.61e-06	(9.53e-06)
Hospital Annual PCI Volume	7.56e-06*	(3.33e-06)
Years as MD	-9.65e-05**	(3.35e-05)
Observations	433,591	
R2	0.037	
Number of Fixed Effects	1,123	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

I find no mortality difference between primary and secondary hospitals on days when the physician only worked in 1 hospital. On days the physician worked in more than 1 hospital, I find that adjusted 10 day mortality is 32% higher in their secondary hospitals compared to their primary. 10 day mortality after PCI is 2.21% in the secondary hospital versus 1.67% in the primary hospital. While higher, I don't find that secondary hospitals have statistically different mortality rates between 1 and more than 1 hospital days. And for primary hospitals, I find that mortality rates are slightly lower on multihospital days (insignificantly so), suggesting that multihospital days may be more likely when the physician has healthier patients in their primary hospital. While not conclusive, these findings support the hypothesis that the availability of the physician before the PCI (and possibly after) contributes to the mortality difference between solo and multihospital physicians observed in chapter 7.

Figure 8.3 – The Relation between 10 Day Mortality after PCI and Same-Day Multihospital Practice by Primary or Secondary Hospital Status (to the Physician)



Chapter 9: Summary of Findings

In this chapter I summarize the findings of my dissertation. The findings below refer to my study sample and study setting.

Summary of Findings

Chapter 5: Regional Variation in Multihospital Practice

- There is substantial variation in the prevalence of multihospital practice in interventional cardiology across hospital referral regions.
- Differences between regions explain 85.6% of the variation.
- Within region variation is related to the number of PCI hospitals (≥10 PCI per year) per 10,000 Medicare enrollees (i.e., per capita), where multihospital practice is more commonplace in regions with more hospitals per capita.
- Within region variation is also related to the number of physicians per PCI hospital: regions with more physicians per hospital have relatively fewer multihospital practices.

Chapter 6: Development of an Exogenous Measure of Multihospital Practice

- At the physician-year level, multihospital physicians do 34.7% more PCI than solo-hospital physicians. Conditional on physician market, they do 72% more. This difference in PCI volume, which would be the return from multihospital practice, is valued at $37,515.
- Physicians with the lowest probability of multihospital practice (at 11.29%) were located in markets with 1 large PCI hospital (≥40 PCI per year) and 0 small PCI hospitals (<40 PCI per year).

- Physicians with the highest probability of multihospital practice (at 50.1%) were located in markets with 4 or 5 large PCI hospitals in close proximity, with an additional 3 or more small PCI hospitals within the market boundary (i.e. 25 miles in any direction).
- Jointly, the instruments used are strongly predictive of multihospital practice (F-test: 21.43; p<.001).

Chapter 7: Multihospital Practice, Patient Injury and Death

Differences in Observed PCI Characteristics

- Based on observed characteristics at the PCI level:
    - Solo-hospital physicians deliver more emergent PCI, while multihospital physicians deliver more elective PCI
    - PCI delivered by multihospital physicians are on average performed by physicians with less volume in the patient's hospital, but more overall PCI volume (which includes volume from other PCI hospitals).
    - PCI delivered by multihospital physicians are less likely to be from a physician that graduated from a top 29 medical school.
    - Solo-hospital physicians deliver more PCI in higher volume hospitals, teaching hospitals, not-for profit hospitals, hospitals with cardiac care or adult cardiac surgery programs, hospitals with more RNs per bed, and hospitals that see disproportionately fewer Medicaid admissions
- Solo-hospital physicians appear to see sicker patients, but they work in higher quality hospitals, have more prestigious educations, and they do more volume in the patient's hospital.

- Multihospital physicians see healthier patients, work in for-profit lower quality PCI hospitals, are more likely to be foreign trained, and they do less volume in a patient's hospital.

PCI Hospital Choice Model

- On average, hospitals were 26 miles from patient residences, and patients had 12 hospitals to choose from (within a 50 mile radius).
- Patients have a distaste for hospitals that are farther from their homes.
- A one mile increase in the distance from the patient's home to a PCI hospital lowers the probability they will pick that hospital by 0.85 percentage points.

Injury Models

- Roughly 10 to 11% of PCI patients have an injury during their hospital stay.
- Injuries likely due to medical error are less frequent (less than 2%) and they become less so over the study period.
- Expected injury rates are statistically different between quartiles 1 and 4 of instrumented multihospital practice. However, they are very close and almost indistinguishable for injuries likely due to medical error and injuries from puncture, suggesting that patient severity is balanced overall in the medical error models.
- The F-tests (Table 7.5) for overidentification pick up on these differences, The "any injury" and injury unlikely due to medical error models appear to be overidentified.
- The base model without any fixed effect also appears to be overidentified, suggesting that the instruments become valid only when regional (or hospital, which is a lower level than region) effects are included.

- In all models, instrumented multihospital practice is unrelated to patient injuries, including those likely due to medical error.
- Focusing on the hospital fixed effect models shown in Table 7.4.C, patient injury from medical error is related to physician volume (i.e. experience) in a patient's hospital and other hospitals: more volume lowers the probability of patient injury from medical error. Years as an physician also is significantly related to injury, where more tenured physicians are less likely to injure their patients.
- While significant, the effect is quite small: each additional PCI a physician delivers in a patient's hospital would lower the probability of injury from medical error by 0.0000158.
- Based on these estimates, multihospital practice could conceivably influence patient injury from medical error if it increased the physician's volume.
- However, because the volume-injury relation is so small in magnitude, the amount of volume needed to sizably change the probability of injury from medical error would need to be unrealistically large.
- For example, if a physician went from the 5^{th} percentile of physician-hospital-year volume (taken at the physician-hospital-year level) to the 95^{th} percentile, they would increase their volume in a patient's hospital from 1 PCI to 83 PCI a year. This is a massive change in PCI volume.
- If this happened, and using the estimates from Table 7.4.C., then the probability of patient injury from medical error would fall 8%, from 1.62% to 1.49%.

Mortality Models

- Roughly 2.5% of patients die within 30 days of their PCI
- Most of these occur within 10 days of the PCI and while the patient is still in the hospital

- Expected mortality rates are similar between quartiles 1 and 4 of instrumented multihospital practice. This suggests that patient severity (based on observed patient characteristics) is balanced.
- Based on the F-tests in Table 7.8, the base model without any fixed effect is overidentified. The models with regional fixed effects (and hospital fixed effects) are not, which suggests that including the region fixed effect controls for some residual confounding influence in the error term. Only after, the instruments appear to be valid.
- Focusing on the hospital fixed effect models, mortality (inhospital, 10 day, and 30 day) is related to instrumented multihospital practice.
    - Moving from quartile 1 to quartile 4 of $\bar{M}\bar{H}_{jt}$ increases the probability of inhospital mortality from 1.61% to 1.89% (an increase of 17.3%).
    - Moving from quartile 1 to quartile 4 of $\bar{M}\bar{H}_{jt}$ increases the probability of 30 day mortality from 2.31% to 2.66% (an increase of 15.1%).
- Tenure (i.e. years) as a physician is also significantly related to lower mortality.
- Annual PCI volumes (physician or hospital) are not related to differences in mortality.
- Given that I found a volume-injury relation, this suggests that reduced injuries from greater volumes are not contributing to mortality differences in any noticeable way.
- Based on my conceptual model (Figure 7.1), this leaves the availability of the physician before and after PCI as the likely mechanism connecting multihospital practice with patient mortality. And because I found no evidence of a relation between multihospital practice and injury, it's unlikely the relation is driven by the availability of the physician after PCI (unless it's availability after hospital discharge). If it were, then there would be an association with patient injuries.
- Therefore, the availability of the physician before PCI may be the mechanism connecting multihospital practice with patient mortality.

Comparison to Endogenous Models

- Uncorrected multihospital practice holds no significant relation with mortality outcomes.
- This indicates a favorable selection into multihospital practices that biases uncorrected results toward finding no detrimental effect.
- Visually comparing the adjusted mortality rates between the uncorrected and corrected measures of multihospital practice suggests that the bias is really an unfavorable selection into solo-hospital practices.
- Unobserved factors (like unmeasured patient severity) appear to be making solo-hospital performance worse than it actually is.

Chapter 8: Additional Analyses

Why is physician PCI volume related to patient injury, but not patient mortality?

- I find that physician volume does hold a significant relation with unadjusted patient mortality. However, the significance goes away after adjusting for differences in patient severity. This suggests that high volume physicians see relatively healthier patients.
- One possibility is that patient injury from medical error is not primarily due to patient severity. Rather, injuries from medical errors like puncture are based on physician differences like procedure experience or physician ability.
- Mortality, on the other hand, is primarily based on the severity of the patient, and higher volume physicians deliver relatively more PCI to healthier patients. After accounting for patient severity, the mortality relation goes away while the injury relation remains.
- And, as described above, the volume-injury relation is small in size, making it unlikely to significantly influence mortality rates.

Why is multihospital practice related to patient mortality after PCI?

- Based on my conceptual model, there is only 1 possibility: the availability of the physician before PCI. Other possibilities are unlikely:
    - Observed patient severity is balanced.
    - Hospital fixed effects control for residual differences between hospitals.
    - Instrumented multihospital practice is unrelated to patient injury due to medical error.
        - Familiarity, physician availability after the PCI, and residual unobserved differences in physician ability would all be related to more injury from medical error—which is not the case.
    - Availability of the physician after discharge may matter, however, I do not find any relation between multihospital practice and post-discharge mortality.
- The availability of the physician before the PCI is important because it may be related to longer times-to-balloon.
- More heart damage is created the longer a patient's coronary artery is occluded. So if patients wait longer for multihospital physicians to arrive at their hospital, then patient mortality will be higher for multihospital physicians.
- Because this additional severity is not observed in the data, I pick it up in my instrumented multihospital practice measure as a relation between multihospital practice and mortality.
- And because time-to-balloon is unobserved, I cannot definitively say it explains the difference in mortality rates. However, if it were, then the difference in mortality would be from emergent PCI that were admitted through the emergency department (ED) or transferred to their hospital.

- I find that instrumented multihospital practice and mortality are unrelated for outpatients and referral admissions (i.e. elective PCI)—patients that likely selected their physician.
- Instrumented multihospital practice and mortality is significantly related among ED and transfer patients.
- I also cannot observe when a physician is unavailable before PCI. However, I can observe days in which the physician works in multiple hospitals.
- Using the uncorrected measure of multihospital practice and an indicator for days in which they worked in multiple hospitals, I create a categorical variable for:
    - Solo-hospital physician
    - Multihospital physician on days they worked in 1 hospital, and
    - Multihospital physician on days they worked in more than 1 hospital
- Interacting this variable with the physician's hospital volume, I find that multihospital physicians are no different than solo-hospital physicians on days they only worked in 1 hospital. Moreover, volume does not appear to matter on these days.
- There is significant mortality difference on days the physician worked in multiple hospitals and it appears to diminish with more physician volume in the hospital.
- In a final model, I look at multihospital physicians only and interact multihospital days with an indicator for whether the hospital is their primary hospital (where they probably were before getting called-in) or a secondary hospital (which probably had an emergent patient).
- I find that 10 day mortality is 32% higher in secondary hospitals compared to primary hospitals on days the physician worked in more than 1.

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Appendices

Table A.4.1 – Study Sample Definition

Sample Description or Step	N=
PCI procedures identified in Part B ("physician") claim records - HCPCS CDs for PCI with a stent (92980, 92981) or DES stent (G0290, G0291), or PCI without a stent (92982, 92984) - 1 PCI procedure per beneficiary claim-performing physician-day identified	1,496,222
Part B claim matched only 1 Part A claim	1,487,621
Part A claim was a STACH that matched to an AHA Annual Survey record - Short term acute care hospitals (STACHs) are identified by Medicare provider numbers with the last 4 digits < 880	1,455,422
Physician UPIN matched to AMA Masterfile record with non-missing variables (e.g., the physician's age was not missing)	1,424,239
The patient's residence ZIP, their physician's office ZIP, and their hospital's address ZIP was geocoded and existed within an HRR for a given year - ZIPs were geocoded using U.S. Census Tiger Shapefiles - HRR to ZIP crosswalks for each year were obtained from the Dartmouth Atlas	1,407,359
PCI billed from secondary physician offices in a year removed: physicians are limited to 1 office ZIP per year - Primary/secondary ZIP locations were identified by PCI volumes in each ZIP	1,362,930
Restrictions based on patient characteristics imposed - Age eligible Medicare without any HMO months - End stage renal disease beneficiaries were removed - Outpatient, or inpatient elective, urgent or emergent PCI only - Only the first PCI delivered in a beneficiary's hospital stay was kept - Primary diagnosis code (i.e., chief reason services were provided) of atherosclerosis (414.XX) or AMI (410.XX) only	1,030,884
Low volume hospitals (< 10 PCI per year) were removed - Before imposing this restriction, there are 2,404 unique hospitals in at least 1 year over the period 2001-2004 - And before, there are 6,630 hospital-years overall - After, there are roughly half as many unique hospitals: 1,276 hospitals in at least 1 year over the period 2001-2004 - After the restriction there are 4,595 hospital-years – 31% less than before	1,027,230

Table A.7.1 – Prevalence of type of injury 2001-2004 (top 20 injuries shown)

Injury	Probability Injury is due to Medical Error	% of Total Injuries
Total injuries, No.	--	142,771
Other complications of internal device	< 10	23.35%
Hematoma complicating a procedure	35-65	22.83%
Complications affecting specified body systems	< 10	17.90%
Accidental puncture or laceration during a procedure, NEC	90 <	7.87%
Hemorrhage complicating a procedure	35-65	6.14%
Hypotension - latrogenic	35-65	4.54%
Abnormal reaction due to other procedures	< 10	2.92%
Substances causing adverse events in therapeutic use	< 10	2.35%
Mechanical complication of cardiac device	10-35	1.16%
Surgical complication of the respiratory system	10-35	1.08%
Iatrogenic cerebrovascular infarction or hemorrhage	90 <	1.06%
Abnormal reaction due to surgery	< 10	1.02%
Pressure ulcer	90 <	0.84%
Infection and reaction due to internal prosthetic device	< 10	0.75%
Dermatitis due to substances taken internally	< 10	0.72%
Complications of medical care	< 10	0.70%
Other complications of adverse events	< 10	0.67%
Postoperative infection	90 <	0.53%
Pneumothorax	35-65	0.37%
Infection following infusion	90 <	0.33%

Table A.7.2.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Occurring during the Patient's Hospital Stay for PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.00408	(0.00348)
Quartile 3	-0.00192	(0.00577)
Quartile 4	0.00795	(0.00636)
Physician Annual PCI Volume		
In the Patient's Hospital	-8.90e-05***	(2.03e-05)
In Other Hospitals	-0.000122**	(3.81e-05)
Hospital Annual PCI Volume	-1.85e-06	(5.12e-06)
Years as MD	-0.000213*	(9.65e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	0.00858	(0.00447)
2500 to 5000	0.00393	(0.00551)
5000 to 10000	0.00516	(0.00577)
0 PCI Hospitals in Market	-0.00798	(0.00893)
Patient Characteristics		
Age 70 to 75	0.00419***	(0.000767)
Age 75 to 80	0.00922***	(0.000909)
Age 80 to 85	0.0113***	(0.00106)
Age 85 & Over	0.00911***	(0.00139)
Female	0.0249***	(0.000772)
African-American	-0.0178***	(0.00186)
Asian	0.00519	(0.00357)
Other Race	0.00465	(0.00361)
Hispanic	-0.00711*	(0.00347)
Procedure Characteristics		
AMI	0.0430***	(0.00125)
Outpatient	-0.0465***	(0.00230)
Emergency Dept.	0.00148	(0.00255)
Transfer	0.00772***	(0.00196)
Inpatient Urgent	0.00936***	(0.00192)
Inpatient Emergent	0.0169***	(0.00293)
PTCA	0.0596***	(0.00213)
Both - PTCA & Stent	0.0277***	(0.00240)
Multivessel	0.00666*	(0.00271)
Right Coronary Vessel	0.00398	(0.00213)
Left Coronary Vessel	0.000917	(0.00225)
Left Descending Vessel	0.00209	(0.00216)
Drug-Eluting Stent (Post April 2003)	-0.00912***	(0.00130)
Weekend	0.00709***	(0.00150)
Patient Comorbidities		
Congestive Heart Failure	0.0101***	(0.00155)
Valvular Disease	0.00995***	(0.00242)
Pulmonary Circulation Disorder	-0.00654	(0.00535)
Peripheral Vascular Disease	0.0226***	(0.00111)
Hypertension	-0.0119***	(0.000870)
Paralysis	0.0237***	(0.00304)
Other Neurological Disorders	-0.00213	(0.00231)
Chronic Pulmonary Disease	0.000838	(0.000891)
Diabetes Without Complication	-0.00897***	(0.000735)

Diabetes With Complications	0.000284	(0.00173)
Hypothyroidism	-0.00472***	(0.00115)
Renal Failure	0.0250***	(0.00212)
Liver Disease	-0.00552	(0.00448)
Chronic Peptic Ulcer Disease	0.00623	(0.0102)
HIV and AIDS	-0.00119	(0.0374)
Lymphoma	-0.00540	(0.00500)
Metastatic Cancer	-0.0108**	(0.00362)
Solid Tumor without Metastasis	-0.00806***	(0.00191)
Rheumatoid Arthritis	0.00142	(0.00219)
Coagulation Deficiency	0.0719***	(0.00258)
Obesity	-0.00299*	(0.00147)
Weight Loss	0.0195***	(0.00363)
Fluid and Electrolyte Disorders	0.0221***	(0.00124)
Blood Loss Anemia	0.0375***	(0.00288)
Deficiency Anemias	0.0116***	(0.00124)
Alcohol Abuse	-0.00261	(0.00389)
Drug Abuse	0.0291***	(0.00864)
Psychoses	-0.00589	(0.00354)
Depression	-0.00866***	(0.00153)
Physician Medical School Training		
30+ Ranked MD School	-0.00790***	(0.00189)
Foreign Trained	-0.0130***	(0.00232)
Hospital Characteristics		
For-profit	-0.00366	(0.00318)
Government	-0.0105*	(0.00460)
Teaching	0.0124***	(0.00367)
System	-0.00214	(0.00272)
Cardiac Intensive Care	0.00241	(0.00260)
Adult Cardiac Surgery	0.00140	(0.00359)
Hospital Beds	8.24e-06	(5.51e-06)
RNs per Bed	0.0115***	(0.00221)
Medicaid Share of Admissions	0.0276	(0.0160)
Year of PCI		
2002	0.00453***	(0.00124)
2003	0.00930***	(0.00156)
2004	0.00630	(0.00362)
Observations	1,027,230	
R-squared	0.024	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.2.2—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Unlikely Due to Medical Error Occurring during the Patient's Hospital Stay for PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.00280	(0.00272)
Quartile 3	-0.000703	(0.00439)
Quartile 4	0.00798	(0.00492)
Physician Annual PCI Volume		
In the Patient's Hospital	-3.29e-05	(1.78e-05)
In Other Hospitals	-9.00e-05**	(2.86e-05)
Hospital Annual PCI Volume	2.26e-06	(3.96e-06)
Years as MD	-9.96e-05	(7.59e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	0.0102**	(0.00346)
2500 to 5000	0.00763	(0.00402)
5000 to 10000	0.00639	(0.00431)
0 PCI Hospitals in Market	-0.00133	(0.00641)
Patient Characteristics		
Age 70 to 75	0.00111	(0.000619)
Age 75 to 80	0.00298***	(0.000730)
Age 80 to 85	0.00331***	(0.000822)
Age 85 & Over	0.000690	(0.00102)
Female	0.00397***	(0.000594)
African-American	-0.00876***	(0.00149)
Asian	0.000647	(0.00257)
Other Race	0.00344	(0.00274)
Hispanic	-0.00764**	(0.00280)
Procedure Characteristics		
AMI	0.0252***	(0.000918)
Outpatient	-0.0223***	(0.00172)
Emergency Dept.	0.00135	(0.00210)
Transfer	0.00236	(0.00147)
Inpatient Urgent	0.00557***	(0.00158)
Inpatient Emergent	0.0101***	(0.00235)
PTCA	0.0581***	(0.00191)
Both - PTCA & Stent	0.0264***	(0.00202)
Multivessel	0.00382	(0.00203)
Right Coronary Vessel	0.00246	(0.00157)
Left Coronary Vessel	0.00212	(0.00163)
Left Descending Vessel	0.00108	(0.00157)
Drug-Eluting Stent (Post April 2003)	-0.00426***	(0.00103)
Weekend	0.00481***	(0.00114)
Patient Comorbidities		
Congestive Heart Failure	0.00897***	(0.00133)
Valvular Disease	0.00554**	(0.00202)
Pulmonary Circulation Disorder	-0.00704	(0.00401)
Peripheral Vascular Disease	0.0188***	(0.000975)
Hypertension	-0.00649***	(0.000663)
Paralysis	-0.00225	(0.00212)
Other Neurological Disorders	-0.00525**	(0.00161)
Chronic Pulmonary Disease	-0.000179	(0.000775)

Diabetes Without Complication	-0.000904	(0.000590)
Diabetes With Complications	0.00469***	(0.00142)
Hypothyroidism	-0.00274**	(0.000848)
Renal Failure	0.0217***	(0.00189)
Liver Disease	-0.00279	(0.00386)
Chronic Peptic Ulcer Disease	0.00506	(0.00910)
HIV and AIDS	-0.0160	(0.0252)
Lymphoma	-0.00550	(0.00401)
Metastatic Cancer	-0.00586*	(0.00278)
Solid Tumor without Metastasis	-0.00338*	(0.00160)
Rheumatoid Arthritis	-0.00175	(0.00171)
Coagulation Deficiency	0.0431***	(0.00215)
Obesity	-0.00451***	(0.00107)
Weight Loss	0.00899**	(0.00302)
Fluid and Electrolyte Disorders	0.0115***	(0.000961)
Blood Loss Anemia	0.0171***	(0.00214)
Deficiency Anemias	0.00281**	(0.000944)
Alcohol Abuse	-0.00538	(0.00299)
Drug Abuse	0.0153*	(0.00677)
Psychoses	-0.0104***	(0.00242)
Depression	-0.00536***	(0.00117)
Physician Medical School Training		
30+ Ranked MD School	-0.00464**	(0.00147)
Foreign Trained	-0.00779***	(0.00182)
Hospital Characteristics		
For-profit	0.00104	(0.00256)
Government	-0.0104**	(0.00341)
Teaching	0.00333	(0.00269)
System	0.000998	(0.00215)
Cardiac Intensive Care	0.00253	(0.00223)
Adult Cardiac Surgery	0.000850	(0.00280)
Hospital Beds	7.21e-06	(3.98e-06)
RNs per Bed	0.00771***	(0.00186)
Medicaid Share of Admissions	0.00568	(0.0120)
Year of PCI		
2002	0.00629***	(0.000935)
2003	0.0149***	(0.00117)
2004	0.0127***	(0.00285)
Observations	1,027,230	
R-squared	0.016	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.2.3—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Likely Due to Medical Error Occurring during the Patient's Hospital Stay for PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.000957	(0.00105)
Quartile 3	-0.000658	(0.00146)
Quartile 4	0.000753	(0.00169)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.85e-05***	(4.43e-06)
In Other Hospitals	-2.18e-05**	(7.74e-06)
Hospital Annual PCI Volume	3.41e-06*	(1.66e-06)
Years as MD	-7.34e-05**	(2.60e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	0.000737	(0.00115)
2500 to 5000	0.000934	(0.00136)
5000 to 10000	0.00270	(0.00150)
0 PCI Hospitals in Market	0.000341	(0.00213)
Patient Characteristics		
Age 70 to 75	0.000773*	(0.000328)
Age 75 to 80	0.00167***	(0.000349)
Age 80 to 85	0.00179***	(0.000414)
Age 85 & Over	0.00289***	(0.000535)
Female	0.00657***	(0.000318)
African-American	-0.00431***	(0.000619)
Asian	0.00141	(0.00131)
Other Race	0.000170	(0.00123)
Hispanic	-0.00112	(0.00104)
Procedure Characteristics		
AMI	0.00474***	(0.000427)
Outpatient	-0.00948***	(0.000545)
Emergency Dept.	-0.000904	(0.000654)
Transfer	0.00162**	(0.000547)
Inpatient Urgent	0.000219	(0.000523)
Inpatient Emergent	0.00132	(0.000746)
PTCA	0.00595***	(0.000568)
Both - PTCA & Stent	0.00384***	(0.000834)
Multivessel	0.00229**	(0.000765)
Right Coronary Vessel	-0.000272	(0.000583)
Left Coronary Vessel	-0.000461	(0.000580)
Left Descending Vessel	-5.32e-05	(0.000598)
Drug-Eluting Stent (Post April 2003)	-0.00388***	(0.000412)
Weekend	8.84e-05	(0.000528)
Patient Comorbidities		
Congestive Heart Failure	0.00461***	(0.000669)
Valvular Disease	0.00237*	(0.00102)
Pulmonary Circulation Disorder	0.00299	(0.00243)
Peripheral Vascular Disease	0.00326***	(0.000445)
Hypertension	-0.00347***	(0.000322)
Paralysis	0.0310***	(0.00192)
Other Neurological Disorders	0.00353***	(0.00101)
Chronic Pulmonary Disease	0.000598	(0.000326)

Diabetes Without Complication	-0.00163***	(0.000275)
Diabetes With Complications	0.00125	(0.000716)
Hypothyroidism	-0.00218***	(0.000393)
Renal Failure	0.00188*	(0.000768)
Liver Disease	-0.00345*	(0.00167)
Chronic Peptic Ulcer Disease	-0.000932	(0.00406)
HIV and AIDS	0.00347	(0.0134)
Lymphoma	0.000142	(0.00205)
Metastatic Cancer	-0.000205	(0.00146)
Solid Tumor without Metastasis	-0.00169*	(0.000741)
Rheumatoid Arthritis	-0.000344	(0.000998)
Coagulation Deficiency	0.0107***	(0.00107)
Obesity	-0.00147**	(0.000507)
Weight Loss	0.0148***	(0.00193)
Fluid and Electrolyte Disorders	0.00490***	(0.000503)
Blood Loss Anemia	0.00691***	(0.00107)
Deficiency Anemias	-0.000352	(0.000489)
Alcohol Abuse	0.00101	(0.00143)
Drug Abuse	0.00526	(0.00381)
Psychoses	6.49e-05	(0.00143)
Depression	-0.00164**	(0.000590)
Physician Medical School Training		
30+ Ranked MD School	-0.00107	(0.000637)
Foreign Trained	-0.00274***	(0.000657)
Hospital Characteristics		
For-profit	-0.00113	(0.000796)
Government	-0.00185	(0.00124)
Teaching	0.00391***	(0.00108)
System	-0.000463	(0.000748)
Cardiac Intensive Care	0.000149	(0.000618)
Adult Cardiac Surgery	-0.000490	(0.000910)
Hospital Beds	-1.88e-06	(1.31e-06)
RNs per Bed	0.00132	(0.000714)
Medicaid Share of Admissions	0.000155	(0.00435)
Year of PCI		
2002	-0.000854	(0.000462)
2003	-0.00381***	(0.000537)
2004	-0.00208*	(0.000939)
Observations	1,027,230	
R-squared	0.006	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.2.4—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Punctures Occurring during the Patient's Hospital Stay for PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	-0.000797	(0.000971)
Quartile 3	-0.000623	(0.00129)
Quartile 4	0.000973	(0.00155)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.56e-05***	(4.20e-06)
In Other Hospitals	-1.69e-05*	(7.27e-06)
Hospital Annual PCI Volume	2.87e-06	(1.67e-06)
Years as MD	-6.37e-05**	(2.40e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	0.00122	(0.00105)
2500 to 5000	0.00149	(0.00122)
5000 to 10000	0.00320*	(0.00137)
0 PCI Hospitals in Market	0.000907	(0.00189)
Patient Characteristics		
Age 70 to 75	0.000591*	(0.000272)
Age 75 to 80	0.000772**	(0.000290)
Age 80 to 85	0.000691*	(0.000332)
Age 85 & Over	0.00135**	(0.000445)
Female	0.00530***	(0.000259)
African-American	-0.00423***	(0.000485)
Asian	0.000855	(0.00102)
Other Race	0.00102	(0.00110)
Hispanic	-0.00102	(0.000857)
Procedure Characteristics		
AMI	0.000644	(0.000338)
Outpatient	-0.00790***	(0.000486)
Emergency Dept.	-0.00121*	(0.000593)
Transfer	0.000424	(0.000499)
Inpatient Urgent	-0.000252	(0.000474)
Inpatient Emergent	0.000340	(0.000688)
PTCA	0.00479***	(0.000498)
Both - PTCA & Stent	0.00308***	(0.000737)
Multivessel	0.00117	(0.000691)
Right Coronary Vessel	7.93e-05	(0.000512)
Left Coronary Vessel	0.000284	(0.000530)
Left Descending Vessel	0.000565	(0.000545)
Drug-Eluting Stent (Post April 2003)	-0.00356***	(0.000376)
Weekend	-0.000394	(0.000439)
Patient Comorbidities		
Congestive Heart Failure	0.000211	(0.000508)
Valvular Disease	0.00114	(0.000854)
Pulmonary Circulation Disorder	0.00401*	(0.00198)
Peripheral Vascular Disease	0.00269***	(0.000392)
Hypertension	-0.00164***	(0.000277)
Paralysis	0.00157	(0.00102)
Other Neurological Disorders	0.000428	(0.000704)
Chronic Pulmonary Disease	0.000654*	(0.000269)
Diabetes Without Complication	-0.00174***	(0.000221)

Diabetes With Complications	-0.00123*	(0.000551)
Hypothyroidism	-0.00135***	(0.000333)
Renal Failure	-0.00118*	(0.000538)
Liver Disease	-0.00105	(0.00142)
Chronic Peptic Ulcer Disease	-0.00403	(0.00327)
HIV and AIDS	-0.00863***	(0.000824)
Lymphoma	-0.000394	(0.00175)
Metastatic Cancer	-0.000383	(0.00116)
Solid Tumor without Metastasis	-0.00133*	(0.000615)
Rheumatoid Arthritis	-0.000644	(0.000780)
Coagulation Deficiency	0.00814***	(0.000861)
Obesity	-0.000818	(0.000436)
Weight Loss	0.00175	(0.00132)
Fluid and Electrolyte Disorders	0.00245***	(0.000413)
Blood Loss Anemia	0.00431***	(0.000858)
Deficiency Anemias	-0.000367	(0.000388)
Alcohol Abuse	-0.000648	(0.00114)
Drug Abuse	0.00680*	(0.00338)
Psychoses	-0.000649	(0.00105)
Depression	-0.00101*	(0.000481)
Physician Medical School Training		
30+ Ranked MD School	-0.00107	(0.000601)
Foreign Trained	-0.00253***	(0.000619)
Hospital Characteristics		
For-profit	-0.00111	(0.000751)
Government	-0.00175	(0.00114)
Teaching	0.00290**	(0.00103)
System	-0.000605	(0.000699)
Cardiac Intensive Care	0.000193	(0.000555)
Adult Cardiac Surgery	-0.000393	(0.000782)
Hospital Beds	-1.28e-06	(1.26e-06)
RNs per Bed	0.00130	(0.000698)
Medicaid Share of Admissions	-0.00140	(0.00394)
Year of PCI		
2002	-0.000969*	(0.000418)
2003	-0.00404***	(0.000495)
2004	-0.00229**	(0.000821)
Observations	1,027,230	
R-squared	0.003	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.3.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Occurring during the Patient's Hospital Stay for PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.00243	(0.00421)
Quartile 3	-0.00414	(0.00536)
Quartile 4	0.00262	(0.00564)
Physician Annual PCI Volume		
In the Patient's Hospital	-7.10e-05***	(1.80e-05)
In Other Hospitals	-7.33e-05*	(3.07e-05)
Hospital Annual PCI Volume	2.32e-06	(4.73e-06)
Years as MD	-0.000152	(8.07e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	-0.00514	(0.00459)
2500 to 5000	-5.34e-05	(0.00622)
5000 to 10000	-0.00985	(0.00657)
0 PCI Hospitals in Market	-0.0199*	(0.00882)
Patient Characteristics		
Age 70 to 75	0.00391***	(0.000759)
Age 75 to 80	0.00869***	(0.000880)
Age 80 to 85	0.0103***	(0.00102)
Age 85 & Over	0.00794***	(0.00132)
Female	0.0257***	(0.000747)
African-American	-0.0153***	(0.00171)
Asian	0.00220	(0.00351)
Other Race	0.00206	(0.00330)
Hispanic	-0.00306	(0.00312)
Procedure Characteristics		
AMI	0.0418***	(0.00119)
Outpatient	-0.0500***	(0.00261)
Emergency Dept.	0.00466*	(0.00199)
Transfer	0.00632***	(0.00159)
Inpatient Urgent	0.00651***	(0.00146)
Inpatient Emergent	0.0132***	(0.00226)
PTCA	0.0603***	(0.00208)
Both - PTCA & Stent	0.0272***	(0.00230)
Multivessel	0.00519*	(0.00229)
Right Coronary Vessel	0.00471**	(0.00174)
Left Coronary Vessel	0.00151	(0.00185)
Left Descending Vessel	0.00284	(0.00176)
Drug-Eluting Stent (Post April 2003)	-0.0107***	(0.00111)
Weekend	0.00724***	(0.00135)
Patient Comorbidities		
Congestive Heart Failure	0.0116***	(0.00153)
Valvular Disease	0.00701**	(0.00231)
Pulmonary Circulation Disorder	-0.00729	(0.00528)
Peripheral Vascular Disease	0.0218***	(0.00113)
Hypertension	-0.0120***	(0.000818)
Paralysis	0.0242***	(0.00304)
Other Neurological Disorders	-0.00143	(0.00229)
Chronic Pulmonary Disease	0.00135	(0.000847)

Diabetes Without Complication	-0.00827***	(0.000730)
Diabetes With Complications	-0.000314	(0.00173)
Hypothyroidism	-0.00523***	(0.00113)
Renal Failure	0.0255***	(0.00214)
Liver Disease	-0.00636	(0.00447)
Chronic Peptic Ulcer Disease	0.00590	(0.0102)
HIV and AIDS	-0.00655	(0.0369)
Lymphoma	-0.00615	(0.00497)
Metastatic Cancer	-0.0109**	(0.00362)
Solid Tumor without Metastasis	-0.00818***	(0.00191)
Rheumatoid Arthritis	1.45e-05	(0.00216)
Coagulation Deficiency	0.0704***	(0.00253)
Obesity	-0.00495***	(0.00141)
Weight Loss	0.0213***	(0.00361)
Fluid and Electrolyte Disorders	0.0217***	(0.00121)
Blood Loss Anemia	0.0373***	(0.00284)
Deficiency Anemias	0.0107***	(0.00122)
Alcohol Abuse	-0.00460	(0.00385)
Drug Abuse	0.0280**	(0.00860)
Psychoses	-0.00603	(0.00350)
Depression	-0.00938***	(0.00154)
Physician Medical School Training		
30+ Ranked MD School	-0.00329	(0.00170)
Foreign Trained	-0.00524**	(0.00191)
Hospital Characteristics		
For-profit	-0.00390	(0.00360)
Government	0.00185	(0.00577)
Teaching	0.0148***	(0.00378)
System	-0.00219	(0.00298)
Cardiac Intensive Care	0.000611	(0.00232)
Adult Cardiac Surgery	0.00396	(0.00305)
Hospital Beds	1.15e-05	(5.89e-06)
RNs per Bed	0.00732***	(0.00214)
Medicaid Share of Admissions	0.0358*	(0.0152)
Year of PCI		
2002	0.00445***	(0.00119)
2003	0.00936***	(0.00150)
2004	0.00465	(0.00307)
Observations	1,027,230	
R-squared	0.022	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.

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

Table A.7.3.2—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Any Injury Unlikely Due to Medical Error Occurring during the Patient's Hospital Stay for PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	-0.00289	(0.00324)
Quartile 3	-0.00643	(0.00408)
Quartile 4	5.67e-05	(0.00429)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.69e-05	(1.52e-05)
In Other Hospitals	-4.86e-05	(2.81e-05)
Hospital Annual PCI Volume	6.74e-06	(3.71e-06)
Years as MD	-6.23e-05	(6.25e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	-0.00374	(0.00342)
2500 to 5000	0.00223	(0.00476)
5000 to 10000	-0.00775	(0.00489)
0 PCI Hospitals in Market	-0.0127	(0.00652)
Patient Characteristics		
Age 70 to 75	0.000936	(0.000613)
Age 75 to 80	0.00269***	(0.000724)
Age 80 to 85	0.00277***	(0.000793)
Age 85 & Over	-2.85e-05	(0.000967)
Female	0.00444***	(0.000582)
African-American	-0.00768***	(0.00129)
Asian	0.00104	(0.00254)
Other Race	0.00209	(0.00256)
Hispanic	-0.00401	(0.00207)
Procedure Characteristics		
AMI	0.0246***	(0.000886)
Outpatient	-0.0230***	(0.00172)
Emergency Dept.	0.00297	(0.00160)
Transfer	0.00213	(0.00121)
Inpatient Urgent	0.00337**	(0.00111)
Inpatient Emergent	0.00839***	(0.00171)
PTCA	0.0587***	(0.00187)
Both - PTCA & Stent	0.0262***	(0.00201)
Multivessel	0.00108	(0.00173)
Right Coronary Vessel	0.00415**	(0.00132)
Left Coronary Vessel	0.00372**	(0.00137)
Left Descending Vessel	0.00279*	(0.00129)
Drug-Eluting Stent (Post April 2003)	-0.00502***	(0.000892)
Weekend	0.00478***	(0.00102)
Patient Comorbidities		
Congestive Heart Failure	0.00977***	(0.00132)
Valvular Disease	0.00386*	(0.00186)
Pulmonary Circulation Disorder	-0.00758	(0.00393)
Peripheral Vascular Disease	0.0187***	(0.000919)
Hypertension	-0.00643***	(0.000629)
Paralysis	-0.00188	(0.00212)

Other Neurological Disorders	-0.00479**	(0.00159)
Chronic Pulmonary Disease	0.000301	(0.000723)
Diabetes Without Complication	-0.000384	(0.000579)
Diabetes With Complications	0.00427**	(0.00142)
Hypothyroidism	-0.00323***	(0.000840)
Renal Failure	0.0222***	(0.00189)
Liver Disease	-0.00275	(0.00385)
Chronic Peptic Ulcer Disease	0.00482	(0.00906)
HIV and AIDS	-0.0191	(0.0251)
Lymphoma	-0.00571	(0.00398)
Metastatic Cancer	-0.00579*	(0.00276)
Solid Tumor without Metastasis	-0.00332*	(0.00159)
Rheumatoid Arthritis	-0.00260	(0.00171)
Coagulation Deficiency	0.0419***	(0.00208)
Obesity	-0.00571***	(0.00105)
Weight Loss	0.00976**	(0.00300)
Fluid and Electrolyte Disorders	0.0111***	(0.000943)
Blood Loss Anemia	0.0168***	(0.00210)
Deficiency Anemias	0.00222*	(0.000909)
Alcohol Abuse	-0.00647*	(0.00298)
Drug Abuse	0.0144*	(0.00676)
Psychoses	-0.0106***	(0.00238)
Depression	-0.00577***	(0.00118)
Physician Medical School Training		
30+ Ranked MD School	-0.00153	(0.00117)
Foreign Trained	-0.00331*	(0.00135)
Hospital Characteristics		
For-profit	0.00163	(0.00301)
Government	-0.00213	(0.00403)
Teaching	0.00593*	(0.00268)
System	-0.00100	(0.00221)
Cardiac Intensive Care	0.000928	(0.00162)
Adult Cardiac Surgery	0.00193	(0.00247)
Hospital Beds	9.11e-06*	(3.68e-06)
RNs per Bed	0.00511**	(0.00186)
Medicaid Share of Admissions	0.0188	(0.0109)
Year of PCI		
2002	0.00641***	(0.000908)
2003	0.0149***	(0.00111)
2004	0.0117***	(0.00250)
Observations	1,027,230	
R-squared	0.015	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.3.3—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Likely Due to Medical Error Occurring during the Patient's Hospital Stay for PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.000763	(0.000966)
Quartile 3	-0.000619	(0.00121)
Quartile 4	0.000694	(0.00142)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.49e-05***	(3.73e-06)
In Other Hospitals	-8.82e-06	(6.87e-06)
Hospital Annual PCI Volume	6.47e-06***	(1.29e-06)
Years as MD	-9.37e-05***	(2.25e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	-0.000364	(0.00113)
2500 to 5000	0.00165	(0.00148)
5000 to 10000	0.00185	(0.00162)
0 PCI Hospitals in Market	-0.00125	(0.00225)
Patient Characteristics		
Age 70 to 75	0.000710*	(0.000327)
Age 75 to 80	0.00152***	(0.000348)
Age 80 to 85	0.00153***	(0.000410)
Age 85 & Over	0.00252***	(0.000521)
Female	0.00681***	(0.000316)
African-American	-0.00286***	(0.000588)
Asian	-0.000338	(0.00135)
Other Race	-0.000506	(0.00118)
Hispanic	-0.000932	(0.000980)
Procedure Characteristics		
AMI	0.00438***	(0.000414)
Outpatient	-0.0109***	(0.000830)
Emergency Dept.	-0.000584	(0.000531)
Transfer	0.00108*	(0.000465)
Inpatient Urgent	0.000173	(0.000408)
Inpatient Emergent	0.000890	(0.000596)
PTCA	0.00593***	(0.000547)
Both - PTCA & Stent	0.00354***	(0.000813)
Multivessel	0.00220**	(0.000727)
Right Coronary Vessel	-0.000247	(0.000520)
Left Coronary Vessel	-0.000494	(0.000518)
Left Descending Vessel	1.66e-06	(0.000509)
Drug-Eluting Stent (Post April 2003)	-0.00426***	(0.000372)
Weekend	-7.12e-05	(0.000487)
Patient Comorbidities		
Congestive Heart Failure	0.00500***	(0.000676)
Valvular Disease	0.00182	(0.00103)
Pulmonary Circulation Disorder	0.00269	(0.00240)
Peripheral Vascular Disease	0.00304***	(0.000424)
Hypertension	-0.00352***	(0.000308)
Paralysis	0.0311***	(0.00191)
Other Neurological Disorders	0.00373***	(0.00101)
Chronic Pulmonary Disease	0.000675*	(0.000321)

Diabetes Without Complication	-0.00148***	(0.000270)
Diabetes With Complications	0.00104	(0.000723)
Hypothyroidism	-0.00233***	(0.000395)
Renal Failure	0.00180*	(0.000769)
Liver Disease	-0.00378*	(0.00166)
Chronic Peptic Ulcer Disease	-0.000827	(0.00404)
HIV and AIDS	0.00133	(0.0132)
Lymphoma	-0.000177	(0.00204)
Metastatic Cancer	-0.000256	(0.00145)
Solid Tumor without Metastasis	-0.00176*	(0.000742)
Rheumatoid Arthritis	-0.000710	(0.000991)
Coagulation Deficiency	0.0105***	(0.00107)
Obesity	-0.00193***	(0.000475)
Weight Loss	0.0153***	(0.00190)
Fluid and Electrolyte Disorders	0.00489***	(0.000486)
Blood Loss Anemia	0.00695***	(0.00107)
Deficiency Anemias	-0.000384	(0.000484)
Alcohol Abuse	0.000670	(0.00142)
Drug Abuse	0.00522	(0.00380)
Psychoses	0.000116	(0.00142)
Depression	-0.00178**	(0.000589)
Physician Medical School Training		
30+ Ranked MD School	-0.000464	(0.000578)
Foreign Trained	-0.00108	(0.000563)
Hospital Characteristics		
For-profit	-0.00152	(0.000830)
Government	0.000835	(0.00173)
Teaching	0.00444***	(0.000998)
System	0.000156	(0.000659)
Cardiac Intensive Care	0.000180	(0.000599)
Adult Cardiac Surgery	0.000233	(0.000804)
Hospital Beds	-1.37e-06	(1.23e-06)
RNs per Bed	0.000315	(0.000619)
Medicaid Share of Admissions	0.00264	(0.00386)
Year of PCI		
2002	-0.000875	(0.000448)
2003	-0.00379***	(0.000526)
2004	-0.00250**	(0.000861)
Observations	1,027,230	
R-squared	0.006	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.3.4—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Punctures Occurring during the Patient's Hospital Stay for PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.000461	(0.000908)
Quartile 3	-0.000224	(0.00112)
Quartile 4	0.00140	(0.00135)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.19e-05***	(3.33e-06)
In Other Hospitals	-6.82e-06	(6.11e-06)
Hospital Annual PCI Volume	5.56e-06***	(1.34e-06)
Years as MD	-8.56e-05***	(2.03e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	0.000227	(0.00101)
2500 to 5000	0.00215	(0.00140)
5000 to 10000	0.00279	(0.00151)
0 PCI Hospitals in Market	-0.000378	(0.00205)
Patient Characteristics		
Age 70 to 75	0.000549*	(0.000274)
Age 75 to 80	0.000674*	(0.000288)
Age 80 to 85	0.000505	(0.000328)
Age 85 & Over	0.00107*	(0.000428)
Female	0.00548***	(0.000260)
African-American	-0.00295***	(0.000454)
Asian	-0.000445	(0.00105)
Other Race	0.000624	(0.00105)
Hispanic	-0.000478	(0.000786)
Procedure Characteristics		
AMI	0.000305	(0.000331)
Outpatient	-0.00932***	(0.000768)
Emergency Dept.	-0.000903*	(0.000452)
Transfer	-1.64e-05	(0.000418)
Inpatient Urgent	-0.000221	(0.000356)
Inpatient Emergent	-0.000102	(0.000492)
PTCA	0.00478***	(0.000483)
Both - PTCA & Stent	0.00285***	(0.000718)
Multivessel	0.00115	(0.000623)
Right Coronary Vessel	-3.40e-05	(0.000435)
Left Coronary Vessel	0.000123	(0.000442)
Left Descending Vessel	0.000476	(0.000438)
Drug-Eluting Stent (Post April 2003)	-0.00383***	(0.000335)
Weekend	-0.000537	(0.000393)
Patient Comorbidities		
Congestive Heart Failure	0.000548	(0.000508)
Valvular Disease	0.000696	(0.000864)
Pulmonary Circulation Disorder	0.00369	(0.00197)
Peripheral Vascular Disease	0.00241***	(0.000350)
Hypertension	-0.00167***	(0.000261)
Paralysis	0.00171	(0.00102)
Other Neurological Disorders	0.000583	(0.000702)
Chronic Pulmonary Disease	0.000693**	(0.000267)
Diabetes Without Complication	-0.00160***	(0.000215)

Diabetes With Complications	-0.00138*	(0.000559)
Hypothyroidism	-0.00150***	(0.000338)
Renal Failure	-0.00124*	(0.000534)
Liver Disease	-0.00131	(0.00140)
Chronic Peptic Ulcer Disease	-0.00377	(0.00324)
HIV and AIDS	-0.0101***	(0.00104)
Lymphoma	-0.000651	(0.00175)
Metastatic Cancer	-0.000389	(0.00116)
Solid Tumor without Metastasis	-0.00137*	(0.000616)
Rheumatoid Arthritis	-0.000943	(0.000770)
Coagulation Deficiency	0.00798***	(0.000854)
Obesity	-0.00121**	(0.000404)
Weight Loss	0.00207	(0.00131)
Fluid and Electrolyte Disorders	0.00240***	(0.000400)
Blood Loss Anemia	0.00435***	(0.000850)
Deficiency Anemias	-0.000403	(0.000384)
Alcohol Abuse	-0.000882	(0.00114)
Drug Abuse	0.00674*	(0.00337)
Psychoses	-0.000622	(0.00104)
Depression	-0.00117*	(0.000477)
Physician Medical School Training		
30+ Ranked MD School	-0.000648	(0.000526)
Foreign Trained	-0.00107*	(0.000509)
Hospital Characteristics		
For-profit	-0.00138	(0.000751)
Government	0.000788	(0.00160)
Teaching	0.00319***	(0.000881)
System	0.000239	(0.000586)
Cardiac Intensive Care	0.000146	(0.000546)
Adult Cardiac Surgery	-0.000182	(0.000687)
Hospital Beds	6.94e-08	(1.18e-06)
RNs per Bed	0.000300	(0.000580)
Medicaid Share of Admissions	0.00130	(0.00331)
Year of PCI		
2002	-0.00100*	(0.000404)
2003	-0.00403***	(0.000480)
2004	-0.00234**	(0.000761)
Observations	1,027,230	
R-squared	0.003	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.

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

Table A.7.4.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Occurring during the Patient's Hospital Stay for PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.000232	(0.00298)
Quartile 3	0.00175	(0.00382)
Quartile 4	0.00702	(0.00384)
Physician Annual PCI Volume		
In the Patient's Hospital	-7.96e-05***	(1.28e-05)
In Other Hospitals	-6.78e-05**	(2.48e-05)
Hospital Annual PCI Volume	2.26e-06	(8.08e-06)
Years as MD	-0.000145*	(7.05e-05)
Patient Characteristics		
Age 70 to 75	0.00396***	(0.000753)
Age 75 to 80	0.00880***	(0.000879)
Age 80 to 85	0.0105***	(0.00103)
Age 85 & Over	0.00818***	(0.00131)
Female	0.0261***	(0.000749)
African-American	-0.0168***	(0.00157)
Asian	0.00310	(0.00336)
Other Race	0.00114	(0.00323)
Hispanic	-0.00139	(0.00307)
Procedure Characteristics		
AMI	0.0416***	(0.00115)
Outpatient	-0.0522***	(0.00281)
Emergency Dept.	0.00638***	(0.00185)
Transfer	0.00481***	(0.00134)
Inpatient Urgent	0.00598***	(0.00121)
Inpatient Emergent	0.0116***	(0.00212)
PTCA	0.0616***	(0.00203)
Both - PTCA & Stent	0.0285***	(0.00225)
Multivessel	0.00631**	(0.00194)
Right Coronary Vessel	0.00314*	(0.00136)
Left Coronary Vessel	-0.000442	(0.00145)
Left Descending Vessel	0.000979	(0.00140)
Drug-Eluting Stent (Post April 2003)	-0.0113***	(0.00105)
Weekend	0.00804***	(0.00134)
Patient Comorbidities		
Congestive Heart Failure	0.0118***	(0.00152)
Valvular Disease	0.00599**	(0.00229)
Pulmonary Circulation Disorder	-0.00822	(0.00529)
Peripheral Vascular Disease	0.0207***	(0.00111)
Hypertension	-0.0126***	(0.000819)
Paralysis	0.0246***	(0.00302)
Other Neurological Disorders	-0.00157	(0.00226)
Chronic Pulmonary Disease	0.000905	(0.000839)
Diabetes Without Complication	-0.00806***	(0.000717)
Diabetes With Complications	-0.000928	(0.00172)
Hypothyroidism	-0.00598***	(0.00113)
Renal Failure	0.0257***	(0.00213)
Liver Disease	-0.00699	(0.00448)

Chronic Peptic Ulcer Disease	0.00435	(0.00996)
HIV and AIDS	-0.00570	(0.0355)
Lymphoma	-0.00669	(0.00496)
Metastatic Cancer	-0.0113**	(0.00360)
Solid Tumor without Metastasis	-0.00809***	(0.00189)
Rheumatoid Arthritis	-0.000164	(0.00216)
Coagulation Deficiency	0.0694***	(0.00250)
Obesity	-0.00496***	(0.00137)
Weight Loss	0.0211***	(0.00367)
Fluid and Electrolyte Disorders	0.0211***	(0.00119)
Blood Loss Anemia	0.0368***	(0.00282)
Deficiency Anemias	0.0104***	(0.00121)
Alcohol Abuse	-0.00521	(0.00382)
Drug Abuse	0.0260**	(0.00852)
Psychoses	-0.00535	(0.00353)
Depression	-0.00988***	(0.00153)
Physician Medical School Training		
30+ Ranked MD School	-0.00166	(0.00141)
Foreign Trained	-0.00414**	(0.00157)
Year of PCI		
2002	0.00536***	(0.00112)
2003	0.0114***	(0.00146)
2004	0.0116***	(0.00173)
Observations	1,027,230	
R-squared	0.021	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.4.2—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Unlikely Due to Medical Error Occurring during the Patient's Hospital Stay for PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.000734	(0.00229)
Quartile 3	-0.00142	(0.00251)
Quartile 4	0.00410	(0.00275)
Physician Annual PCI Volume		
In the Patient's Hospital	-2.42e-05*	(9.84e-06)
In Other Hospitals	-4.13e-05	(2.24e-05)
Hospital Annual PCI Volume	-5.05e-06	(6.18e-06)
Years as MD	-3.66e-05	(5.33e-05)
Patient Characteristics		
Age 70 to 75	0.000949	(0.000604)
Age 75 to 80	0.00282***	(0.000717)
Age 80 to 85	0.00287***	(0.000790)
Age 85 & Over	0.000124	(0.000965)
Female	0.00466***	(0.000582)
African-American	-0.00829***	(0.00117)
Asian	0.00160	(0.00257)
Other Race	0.000915	(0.00252)
Hispanic	-0.00249	(0.00208)
Procedure Characteristics		
AMI	0.0249***	(0.000852)
Outpatient	-0.0236***	(0.00184)
Emergency Dept.	0.00443**	(0.00140)
Transfer	0.00134	(0.00102)
Inpatient Urgent	0.00308***	(0.000913)
Inpatient Emergent	0.00746***	(0.00155)
PTCA	0.0597***	(0.00186)
Both - PTCA & Stent	0.0278***	(0.00194)
Multivessel	0.00188	(0.00150)
Right Coronary Vessel	0.00275*	(0.00112)
Left Coronary Vessel	0.00203	(0.00117)
Left Descending Vessel	0.00118	(0.00111)
Drug-Eluting Stent (Post April 2003)	-0.00561***	(0.000873)
Weekend	0.00497***	(0.00101)
Patient Comorbidities		
Congestive Heart Failure	0.00972***	(0.00130)
Valvular Disease	0.00318	(0.00184)
Pulmonary Circulation Disorder	-0.00818*	(0.00394)
Peripheral Vascular Disease	0.0179***	(0.000906)
Hypertension	-0.00678***	(0.000633)
Paralysis	-0.00130	(0.00211)
Other Neurological Disorders	-0.00500**	(0.00158)
Chronic Pulmonary Disease	4.42e-05	(0.000710)
Diabetes Without Complication	-0.000308	(0.000570)
Diabetes With Complications	0.00392**	(0.00142)
Hypothyroidism	-0.00377***	(0.000834)
Renal Failure	0.0222***	(0.00188)
Liver Disease	-0.00309	(0.00384)

Chronic Peptic Ulcer Disease	0.00457	(0.00896)
HIV and AIDS	-0.0195	(0.0244)
Lymphoma	-0.00591	(0.00395)
Metastatic Cancer	-0.00616*	(0.00276)
Solid Tumor without Metastasis	-0.00327*	(0.00156)
Rheumatoid Arthritis	-0.00264	(0.00171)
Coagulation Deficiency	0.0413***	(0.00206)
Obesity	-0.00540***	(0.00101)
Weight Loss	0.00924**	(0.00299)
Fluid and Electrolyte Disorders	0.0108***	(0.000936)
Blood Loss Anemia	0.0164***	(0.00209)
Deficiency Anemias	0.00218*	(0.000896)
Alcohol Abuse	-0.00670*	(0.00295)
Drug Abuse	0.0137*	(0.00674)
Psychoses	-0.0100***	(0.00239)
Depression	-0.00599***	(0.00118)
Physician Medical School Training		
30+ Ranked MD School	-0.000183	(0.000965)
Foreign Trained	-0.00259*	(0.00113)
Year of PCI		
2002	0.00705***	(0.000849)
2003	0.0170***	(0.00109)
2004	0.0169***	(0.00128)
Observations	1,027,230	
R-squared	0.015	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.

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

Table A.7.4.3—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Any Injury Likely Due to Medical Error Occurring during the Patient's Hospital Stay for PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.000367	(0.000820)
Quartile 3	-0.000664	(0.00105)
Quartile 4	0.000384	(0.00121)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.58e-05***	(4.02e-06)
In Other Hospitals	-1.41e-05*	(6.62e-06)
Hospital Annual PCI Volume	3.57e-06	(2.61e-06)
Years as MD	-8.91e-05***	(2.30e-05)
Patient Characteristics		
Age 70 to 75	0.000739*	(0.000326)
Age 75 to 80	0.00153***	(0.000346)
Age 80 to 85	0.00157***	(0.000407)
Age 85 & Over	0.00258***	(0.000519)
Female	0.00685***	(0.000317)
African-American	-0.00281***	(0.000616)
Asian	0.000387	(0.00135)
Other Race	-0.000462	(0.00119)
Hispanic	-0.000899	(0.000997)
Procedure Characteristics		
AMI	0.00444***	(0.000421)
Outpatient	-0.0115***	(0.000956)
Emergency Dept.	-0.000183	(0.000561)
Transfer	0.000767	(0.000461)
Inpatient Urgent	-1.38e-06	(0.000392)
Inpatient Emergent	0.000344	(0.000610)
PTCA	0.00597***	(0.000529)
Both - PTCA & Stent	0.00384***	(0.000776)
Multivessel	0.00293***	(0.000700)
Right Coronary Vessel	-0.00100*	(0.000476)
Left Coronary Vessel	-0.00133**	(0.000493)
Left Descending Vessel	-0.000800	(0.000485)
Drug-Eluting Stent (Post April 2003)	-0.00442***	(0.000367)
Weekend	0.000133	(0.000489)
Patient Comorbidities		
Congestive Heart Failure	0.00509***	(0.000677)
Valvular Disease	0.00175	(0.00103)
Pulmonary Circulation Disorder	0.00238	(0.00241)
Peripheral Vascular Disease	0.00284***	(0.000422)
Hypertension	-0.00360***	(0.000312)
Paralysis	0.0311***	(0.00191)
Other Neurological Disorders	0.00371***	(0.00101)
Chronic Pulmonary Disease	0.000638*	(0.000319)
Diabetes Without Complication	-0.00147***	(0.000270)
Diabetes With Complications	0.000891	(0.000721)
Hypothyroidism	-0.00244***	(0.000396)
Renal Failure	0.00179*	(0.000761)
Liver Disease	-0.00375*	(0.00166)

Chronic Peptic Ulcer Disease	-0.000931	(0.00406)
HIV and AIDS	0.00198	(0.0128)
Lymphoma	-0.000314	(0.00205)
Metastatic Cancer	-0.000411	(0.00145)
Solid Tumor without Metastasis	-0.00171*	(0.000744)
Rheumatoid Arthritis	-0.000742	(0.000989)
Coagulation Deficiency	0.0103***	(0.00107)
Obesity	-0.00206***	(0.000474)
Weight Loss	0.0152***	(0.00190)
Fluid and Electrolyte Disorders	0.00479***	(0.000485)
Blood Loss Anemia	0.00676***	(0.00107)
Deficiency Anemias	-0.000373	(0.000481)
Alcohol Abuse	0.000628	(0.00143)
Drug Abuse	0.00462	(0.00380)
Psychoses	0.000318	(0.00142)
Depression	-0.00177**	(0.000585)
Physician Medical School Training		
30+ Ranked MD School	-0.000356	(0.000580)
Foreign Trained	-0.00128*	(0.000567)
Year of PCI		
2002	-0.000762	(0.000453)
2003	-0.00340***	(0.000532)
2004	-0.00169**	(0.000614)
Observations	1,027,230	
R-squared	0.006	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.4.4—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Punctures Occurring during the Patient's Hospital Stay for PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	-0.000257	(0.000728)
Quartile 3	-0.000370	(0.000951)
Quartile 4	0.000952	(0.00110)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.18e-05***	(3.25e-06)
In Other Hospitals	-1.15e-05	(5.89e-06)
Hospital Annual PCI Volume	2.15e-06	(2.33e-06)
Years as MD	-8.31e-05***	(2.04e-05)
Patient Characteristics		
Age 70 to 75	0.000563*	(0.000273)
Age 75 to 80	0.000673*	(0.000287)
Age 80 to 85	0.000508	(0.000324)
Age 85 & Over	0.00111**	(0.000427)
Female	0.00553***	(0.000261)
African-American	-0.00295***	(0.000477)
Asian	0.000150	(0.00103)
Other Race	0.000642	(0.00103)
Hispanic	-0.000259	(0.000786)
Procedure Characteristics		
AMI	0.000409	(0.000337)
Outpatient	-0.00997***	(0.000885)
Emergency Dept.	-0.000437	(0.000492)
Transfer	-0.000289	(0.000410)
Inpatient Urgent	-0.000496	(0.000330)
Inpatient Emergent	-0.000823	(0.000531)
PTCA	0.00485***	(0.000466)
Both - PTCA & Stent	0.00322***	(0.000676)
Multivessel	0.00180**	(0.000602)
Right Coronary Vessel	-0.000709	(0.000397)
Left Coronary Vessel	-0.000633	(0.000410)
Left Descending Vessel	-0.000242	(0.000421)
Drug-Eluting Stent (Post April 2003)	-0.00395***	(0.000328)
Weekend	-0.000355	(0.000390)
Patient Comorbidities		
Congestive Heart Failure	0.000615	(0.000514)
Valvular Disease	0.000631	(0.000861)
Pulmonary Circulation Disorder	0.00341	(0.00198)
Peripheral Vascular Disease	0.00222***	(0.000344)
Hypertension	-0.00174***	(0.000262)
Paralysis	0.00169	(0.00102)
Other Neurological Disorders	0.000577	(0.000701)
Chronic Pulmonary Disease	0.000681*	(0.000265)
Diabetes Without Complication	-0.00160***	(0.000213)
Diabetes With Complications	-0.00148**	(0.000559)
Hypothyroidism	-0.00159***	(0.000339)
Renal Failure	-0.00126*	(0.000528)
Liver Disease	-0.00126	(0.00140)

Chronic Peptic Ulcer Disease	-0.00374	(0.00326)
HIV and AIDS	-0.00956***	(0.00131)
Lymphoma	-0.000741	(0.00175)
Metastatic Cancer	-0.000455	(0.00116)
Solid Tumor without Metastasis	-0.00133*	(0.000618)
Rheumatoid Arthritis	-0.000977	(0.000767)
Coagulation Deficiency	0.00783***	(0.000851)
Obesity	-0.00136***	(0.000397)
Weight Loss	0.00199	(0.00131)
Fluid and Electrolyte Disorders	0.00233***	(0.000398)
Blood Loss Anemia	0.00418***	(0.000847)
Deficiency Anemias	-0.000373	(0.000379)
Alcohol Abuse	-0.000847	(0.00115)
Drug Abuse	0.00625	(0.00337)
Psychoses	-0.000422	(0.00104)
Depression	-0.00114*	(0.000474)
Physician Medical School Training		
30+ Ranked MD School	-0.000470	(0.000526)
Foreign Trained	-0.00122*	(0.000503)
Year of PCI		
2002	-0.000941*	(0.000408)
2003	-0.00374***	(0.000490)
2004	-0.00199***	(0.000578)
Observations	1,027,230	
R-squared	0.003	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.

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

Table A.7.5.1—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Inpatient Death after PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	0.000798	(0.000596)
Quartile 3	0.00103	(0.000938)
Quartile 4	0.00228*	(0.00106)
Physician Annual PCI Volume		
In the Patient's Hospital	-6.55e-06*	(3.33e-06)
In Other Hospitals	-3.79e-06	(8.10e-06)
Hospital Annual PCI Volume	-1.25e-07	(8.44e-07)
Years as MD	-7.31e-05**	(2.27e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	0.00142	(0.000725)
2500 to 5000	0.00140	(0.000913)
5000 to 10000	0.00118	(0.000941)
0 PCI Hospitals in Market	-0.000761	(0.00148)
Patient Characteristics		
Age 70 to 75	0.00267***	(0.000303)
Age 75 to 80	0.00687***	(0.000341)
Age 80 to 85	0.0117***	(0.000453)
Age 85 & Over	0.0200***	(0.000730)
Female	0.00669***	(0.000282)
African-American	0.000677	(0.000675)
Asian	-6.37e-05	(0.00147)
Other Race	0.00139	(0.00126)
Hispanic	0.000714	(0.00129)
Procedure Characteristics		
AMI	0.0408***	(0.000580)
Outpatient	-0.00950***	(0.000476)
Emergency Dept.	0.00144*	(0.000652)
Transfer	-0.000573	(0.000503)
Inpatient Urgent	0.000300	(0.000352)
Inpatient Emergent	0.00518***	(0.000648)
PTCA	0.0143***	(0.000593)
Both - PTCA & Stent	0.00462***	(0.000883)
Multivessel	0.00352***	(0.000664)
Right Coronary Vessel	-0.00251***	(0.000422)
Left Coronary Vessel	-0.00138**	(0.000442)
Left Descending Vessel	0.00304***	(0.000440)
Drug-Eluting Stent (Post April 2003)	-0.0104***	(0.000461)
Weekend	0.0146***	(0.000890)
Patient Comorbidities		
Congestive Heart Failure	-0.0120***	(0.000627)
Valvular Disease	-0.00361***	(0.000828)
Pulmonary Circulation Disorder	0.00232	(0.00215)
Peripheral Vascular Disease	-0.00350***	(0.000343)
Hypertension	-0.0195***	(0.000387)
Paralysis	-0.000198	(0.00126)
Other Neurological Disorders	-0.00122	(0.000905)
Chronic Pulmonary Disease	0.00277***	(0.000380)
Diabetes Without Complication	-0.000755*	(0.000308)

Diabetes With Complications	-0.000796	(0.000754)
Hypothyroidism	-0.00893***	(0.000384)
Renal Failure	0.0225***	(0.00118)
Liver Disease	0.00218	(0.00203)
Chronic Peptic Ulcer Disease	-0.00353	(0.00321)
HIV and AIDS	-0.0169***	(0.00325)
Lymphoma	-0.000499	(0.00216)
Metastatic Cancer	0.00320	(0.00172)
Solid Tumor without Metastasis	-0.00250**	(0.000819)
Rheumatoid Arthritis	-0.00515***	(0.000834)
Coagulation Deficiency	0.0189***	(0.00126)
Obesity	-0.00606***	(0.000361)
Weight Loss	0.00735***	(0.00188)
Fluid and Electrolyte Disorders	0.0223***	(0.000768)
Blood Loss Anemia	-0.00461***	(0.000985)
Deficiency Anemias	-0.0134***	(0.000458)
Alcohol Abuse	-0.00169	(0.00160)
Drug Abuse	-0.00388	(0.00299)
Psychoses	-0.00767***	(0.00113)
Depression	-0.00773***	(0.000508)
Physician Medical School Training		
30+ Ranked MD School	0.00104*	(0.000406)
Foreign Trained	0.000539	(0.000453)
Hospital Characteristics		
For-profit	0.000676	(0.000556)
Government	0.00164*	(0.000793)
Teaching	-0.000466	(0.000534)
System	0.000805	(0.000426)
Cardiac Intensive Care	0.000185	(0.000451)
Adult Cardiac Surgery	0.000861	(0.000736)
Hospital Beds	3.15e-07	(8.88e-07)
RNs per Bed	0.000357	(0.000387)
Medicaid Share of Admissions	0.0109***	(0.00263)
Year of PCI		
2002	-0.000635	(0.000399)
2003	0.00185***	(0.000472)
2004	0.00551***	(0.000819)
Observations	1,027,230	
R-squared	0.045	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.5.2—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Death 10 Days from PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	0.00105	(0.000562)
Quartile 3	0.00149	(0.000849)
Quartile 4	0.00274**	(0.00101)
Physician Annual PCI Volume		
In the Patient's Hospital	-6.84e-06*	(3.06e-06)
In Other Hospitals	-2.50e-07	(7.97e-06)
Hospital Annual PCI Volume	-6.57e-07	(8.65e-07)
Years as MD	-5.99e-05**	(2.18e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	0.00158*	(0.000700)
2500 to 5000	0.00178*	(0.000861)
5000 to 10000	0.00252**	(0.000908)
0 PCI Hospitals in Market	0.00112	(0.00141)
Patient Characteristics		
Age 70 to 75	0.00221***	(0.000317)
Age 75 to 80	0.00632***	(0.000361)
Age 80 to 85	0.0116***	(0.000456)
Age 85 & Over	0.0213***	(0.000747)
Female	0.00624***	(0.000278)
African-American	4.65e-05	(0.000666)
Asian	-0.00130	(0.00146)
Other Race	0.00124	(0.00126)
Hispanic	0.000721	(0.00133)
Procedure Characteristics		
AMI	0.0389***	(0.000553)
Outpatient	-0.00663***	(0.000492)
Emergency Dept.	0.00107	(0.000638)
Transfer	-0.000180	(0.000502)
Inpatient Urgent	0.000285	(0.000360)
Inpatient Emergent	0.00494***	(0.000640)
PTCA	0.0129***	(0.000596)
Both - PTCA & Stent	0.00420***	(0.000877)
Multivessel	0.00489***	(0.000669)
Right Coronary Vessel	-0.00307***	(0.000403)
Left Coronary Vessel	-0.00184***	(0.000417)
Left Descending Vessel	0.00264***	(0.000428)
Drug-Eluting Stent (Post April 2003)	-0.00966***	(0.000474)
Weekend	0.0126***	(0.000865)
Patient Comorbidities		
Congestive Heart Failure	-0.0137***	(0.000606)
Valvular Disease	-0.00457***	(0.000773)
Pulmonary Circulation Disorder	0.00333	(0.00215)
Peripheral Vascular Disease	-0.00165***	(0.000362)
Hypertension	-0.0156***	(0.000381)
Paralysis	0.00329*	(0.00128)
Other Neurological Disorders	0.00105	(0.000925)
Chronic Pulmonary Disease	0.00284***	(0.000382)
Diabetes Without Complication	0.000504	(0.000314)

Diabetes With Complications	-4.13e-05	(0.000744)
Hypothyroidism	-0.00741***	(0.000409)
Renal Failure	0.0164***	(0.00108)
Liver Disease	0.00173	(0.00196)
Chronic Peptic Ulcer Disease	-0.00288	(0.00363)
HIV and AIDS	-0.0156***	(0.00291)
Lymphoma	0.00125	(0.00219)
Metastatic Cancer	0.00591***	(0.00174)
Solid Tumor without Metastasis	-0.001000	(0.000808)
Rheumatoid Arthritis	-0.00349***	(0.000893)
Coagulation Deficiency	0.0115***	(0.00108)
Obesity	-0.00571***	(0.000398)
Weight Loss	-0.00481**	(0.00156)
Fluid and Electrolyte Disorders	0.0195***	(0.000730)
Blood Loss Anemia	-0.00356***	(0.000936)
Deficiency Anemias	-0.0105***	(0.000435)
Alcohol Abuse	-0.000751	(0.00160)
Drug Abuse	-0.000242	(0.00332)
Psychoses	-0.00656***	(0.00119)
Depression	-0.00692***	(0.000557)
Physician Medical School Training		
30+ Ranked MD School	0.00114**	(0.000390)
Foreign Trained	0.000733	(0.000430)
Hospital Characteristics		
For-profit	0.000643	(0.000535)
Government	0.00136	(0.000737)
Teaching	-0.00108*	(0.000507)
System	0.000777	(0.000442)
Cardiac Intensive Care	-0.000544	(0.000425)
Adult Cardiac Surgery	0.000822	(0.000733)
Hospital Beds	4.22e-08	(8.52e-07)
RNs per Bed	9.27e-05	(0.000404)
Medicaid Share of Admissions	0.00775**	(0.00252)
Year of PCI		
2002	-0.000273	(0.000392)
2003	0.00204***	(0.000461)
2004	0.00549***	(0.000808)
Observations	1,027,230	
R-squared	0.037	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** $p<0.001$, ** $p<0.01$, * $p<0.05$

Table A.7.5.3—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Death 30 Days from PCI, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	0.00121	(0.000705)
Quartile 3	0.00217*	(0.00110)
Quartile 4	0.00354**	(0.00127)
Physician Annual PCI Volume		
In the Patient's Hospital	-2.29e-06	(3.94e-06)
In Other Hospitals	6.30e-06	(1.23e-05)
Hospital Annual PCI Volume	1.73e-08	(1.18e-06)
Years as MD	-9.40e-05**	(2.87e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	0.00158	(0.000925)
2500 to 5000	0.00225*	(0.00115)
5000 to 10000	0.00201	(0.00121)
0 PCI Hospitals in Market	0.000887	(0.00188)
Patient Characteristics		
Age 70 to 75	0.00320***	(0.000375)
Age 75 to 80	0.00849***	(0.000440)
Age 80 to 85	0.0160***	(0.000550)
Age 85 & Over	0.0288***	(0.000882)
Female	0.00657***	(0.000348)
African-American	0.000913	(0.000755)
Asian	-0.00161	(0.00174)
Other Race	0.00126	(0.00151)
Hispanic	0.00156	(0.00171)
Procedure Characteristics		
AMI	0.0499***	(0.000653)
Outpatient	-0.00944***	(0.000602)
Emergency Dept.	0.00187*	(0.000752)
Transfer	0.00108	(0.000612)
Inpatient Urgent	0.000620	(0.000448)
Inpatient Emergent	0.00585***	(0.000775)
PTCA	0.0150***	(0.000699)
Both - PTCA & Stent	0.00518***	(0.00100)
Multivessel	0.00624***	(0.000780)
Right Coronary Vessel	-0.00435***	(0.000512)
Left Coronary Vessel	-0.00226***	(0.000531)
Left Descending Vessel	0.00388***	(0.000540)
Drug-Eluting Stent (Post April 2003)	-0.0115***	(0.000553)
Weekend	0.0148***	(0.000996)
Patient Comorbidities		
Congestive Heart Failure	-0.00869***	(0.000820)
Valvular Disease	-0.00546***	(0.00120)
Pulmonary Circulation Disorder	0.00482	(0.00299)
Peripheral Vascular Disease	-0.00250***	(0.000456)
Hypertension	-0.0219***	(0.000470)
Paralysis	0.00928***	(0.00180)
Other Neurological Disorders	0.00265*	(0.00117)
Chronic Pulmonary Disease	0.00655***	(0.000487)
Diabetes Without Complication	0.000271	(0.000388)

Diabetes With Complications	-0.000726	(0.000890)
Hypothyroidism	-0.0103***	(0.000478)
Renal Failure	0.0302***	(0.00146)
Liver Disease	0.00581*	(0.00256)
Chronic Peptic Ulcer Disease	-0.00438	(0.00440)
HIV and AIDS	-0.00846	(0.0141)
Lymphoma	0.00161	(0.00280)
Metastatic Cancer	0.0210***	(0.00248)
Solid Tumor without Metastasis	0.00112	(0.00115)
Rheumatoid Arthritis	-0.00506***	(0.00108)
Coagulation Deficiency	0.0247***	(0.00146)
Obesity	-0.00815***	(0.000500)
Weight Loss	0.0181***	(0.00269)
Fluid and Electrolyte Disorders	0.0297***	(0.000952)
Blood Loss Anemia	-0.00229	(0.00135)
Deficiency Anemias	-0.0136***	(0.000576)
Alcohol Abuse	-0.00106	(0.00202)
Drug Abuse	-0.00227	(0.00413)
Psychoses	-0.00526**	(0.00170)
Depression	-0.00995***	(0.000736)
Physician Medical School Training		
30+ Ranked MD School	0.00152**	(0.000484)
Foreign Trained	0.00146**	(0.000549)
Hospital Characteristics		
For-profit	0.000407	(0.000699)
Government	0.00167	(0.000887)
Teaching	-0.000750	(0.000641)
System	0.000962	(0.000525)
Cardiac Intensive Care	-0.000511	(0.000524)
Adult Cardiac Surgery	0.00112	(0.000885)
Hospital Beds	-1.17e-06	(1.11e-06)
RNs per Bed	-0.000192	(0.000472)
Medicaid Share of Admissions	0.0139***	(0.00314)
Year of PCI		
2002	-0.000712	(0.000482)
2003	0.00226***	(0.000545)
2004	0.00620***	(0.000990)
Observations	1,027,230	
R-squared	0.049	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.5.4—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Death 10 Days from Discharge, Without Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	0.000237	(0.000241)
Quartile 3	0.000562	(0.000361)
Quartile 4	0.000551	(0.000381)
Physician Annual PCI Volume		
In the Patient's Hospital	7.61e-07	(1.41e-06)
In Other Hospitals	4.86e-06	(4.59e-06)
Hospital Annual PCI Volume	-7.31e-08	(3.27e-07)
Years as MD	-1.69e-05	(9.65e-06)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	-0.000119	(0.000265)
2500 to 5000	0.000131	(0.000337)
5000 to 10000	0.000200	(0.000383)
0 PCI Hospitals in Market	0.00142*	(0.000697)
Patient Characteristics		
Age 70 to 75	0.000430**	(0.000160)
Age 75 to 80	0.00117***	(0.000178)
Age 80 to 85	0.00276***	(0.000229)
Age 85 & Over	0.00517***	(0.000397)
Female	0.000446**	(0.000153)
African-American	0.000302	(0.000325)
Asian	-0.000910	(0.000589)
Other Race	-0.000774	(0.000558)
Hispanic	2.80e-06	(0.000562)
Procedure Characteristics		
AMI	0.00768***	(0.000236)
Outpatient	-0.00123***	(0.000199)
Emergency Dept.	0.000147	(0.000288)
Transfer	0.000948***	(0.000269)
Inpatient Urgent	0.000261	(0.000175)
Inpatient Emergent	0.00106***	(0.000277)
PTCA	0.000872***	(0.000244)
Both - PTCA & Stent	0.000340	(0.000415)
Multivessel	0.00201***	(0.000322)
Right Coronary Vessel	-0.00124***	(0.000206)
Left Coronary Vessel	-0.000548**	(0.000200)
Left Descending Vessel	0.000659**	(0.000203)
Drug-Eluting Stent (Post April 2003)	-0.00142***	(0.000203)
Weekend	0.000719*	(0.000348)
Patient Comorbidities		
Congestive Heart Failure	0.000813	(0.000435)
Valvular Disease	-0.00129*	(0.000536)
Pulmonary Circulation Disorder	0.000406	(0.00136)
Peripheral Vascular Disease	-0.000105	(0.000204)
Hypertension	-0.00299***	(0.000186)
Paralysis	0.00420***	(0.000857)
Other Neurological Disorders	0.00246***	(0.000637)
Chronic Pulmonary Disease	0.00197***	(0.000201)
Diabetes Without Complication	0.000305	(0.000168)

Diabetes With Complications	0.000104	(0.000409)
Hypothyroidism	-0.00121***	(0.000217)
Renal Failure	0.00570***	(0.000673)
Liver Disease	0.00203	(0.00122)
Chronic Peptic Ulcer Disease	-0.00272	(0.00164)
HIV and AIDS	0.00323	(0.0104)
Lymphoma	-0.000142	(0.00120)
Metastatic Cancer	0.00601***	(0.00136)
Solid Tumor without Metastasis	0.000866	(0.000544)
Rheumatoid Arthritis	-0.000497	(0.000542)
Coagulation Deficiency	0.00250***	(0.000564)
Obesity	-0.00127***	(0.000218)
Weight Loss	0.00610***	(0.00125)
Fluid and Electrolyte Disorders	0.00411***	(0.000307)
Blood Loss Anemia	-0.000343	(0.000609)
Deficiency Anemias	-0.00126***	(0.000293)
Alcohol Abuse	0.00159	(0.00108)
Drug Abuse	0.00185	(0.00254)
Psychoses	0.000809	(0.000916)
Depression	-0.00177***	(0.000320)
Physician Medical School Training		
30+ Ranked MD School	0.000209	(0.000173)
Foreign Trained	0.000541**	(0.000197)
Hospital Characteristics		
For-profit	-9.84e-05	(0.000266)
Government	0.000182	(0.000335)
Teaching	-0.000203	(0.000202)
System	-3.95e-06	(0.000176)
Cardiac Intensive Care	-0.000390*	(0.000198)
Adult Cardiac Surgery	0.000251	(0.000349)
Hospital Beds	-3.27e-07	(3.51e-07)
RNs per Bed	-7.03e-05	(0.000178)
Medicaid Share of Admissions	0.00202*	(0.00101)
Year of PCI		
2002	4.08e-05	(0.000192)
2003	0.000700***	(0.000206)
2004	0.00101**	(0.000385)
Observations	1,009,044	
R-squared	0.007	

Regression coefficients shown. Standard errors clustered at the physician market level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.6.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inpatient Death after PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.00212**	(0.000765)
Quartile 3	0.00245*	(0.00106)
Quartile 4	0.00294*	(0.00117)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.16e-06	(4.07e-06)
In Other Hospitals	4.13e-07	(8.89e-06)
Hospital Annual PCI Volume	5.36e-07	(9.17e-07)
Years as MD	-8.67e-05***	(2.18e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	0.000277	(0.000927)
2500 to 5000	0.00130	(0.00122)
5000 to 10000	0.000933	(0.00135)
0 PCI Hospitals in Market	-0.000721	(0.00178)
Patient Characteristics		
Age 70 to 75	0.00274***	(0.000303)
Age 75 to 80	0.00701***	(0.000340)
Age 80 to 85	0.0119***	(0.000454)
Age 85 & Over	0.0202***	(0.000725)
Female	0.00661***	(0.000282)
African-American	0.000278	(0.000681)
Asian	0.000103	(0.00147)
Other Race	0.00144	(0.00131)
Hispanic	0.00107	(0.00125)
Procedure Characteristics		
AMI	0.0408***	(0.000574)
Outpatient	-0.00955***	(0.000549)
Emergency Dept.	0.00108	(0.000667)
Transfer	-0.000625	(0.000501)
Inpatient Urgent	0.000555	(0.000368)
Inpatient Emergent	0.00576***	(0.000672)
PTCA	0.0142***	(0.000591)
Both - PTCA & Stent	0.00471***	(0.000878)
Multivessel	0.00373***	(0.000668)
Right Coronary Vessel	-0.00281***	(0.000444)
Left Coronary Vessel	-0.00166***	(0.000461)
Left Descending Vessel	0.00271***	(0.000444)
Drug-Eluting Stent (Post April 2003)	-0.0106***	(0.000459)
Weekend	0.0147***	(0.000884)
Patient Comorbidities		
Congestive Heart Failure	-0.0122***	(0.000626)
Valvular Disease	-0.00360***	(0.000826)
Pulmonary Circulation Disorder	0.00228	(0.00215)
Peripheral Vascular Disease	-0.00369***	(0.000356)
Hypertension	-0.0195***	(0.000387)
Paralysis	-0.000241	(0.00126)
Other Neurological Disorders	-0.00129	(0.000908)
Chronic Pulmonary Disease	0.00266***	(0.000379)
Diabetes Without Complication	-0.000787*	(0.000310)

Diabetes With Complications	-0.000761	(0.000755)
Hypothyroidism	-0.00897***	(0.000382)
Renal Failure	0.0225***	(0.00118)
Liver Disease	0.00211	(0.00203)
Chronic Peptic Ulcer Disease	-0.00291	(0.00324)
HIV and AIDS	-0.0159***	(0.00335)
Lymphoma	-0.000422	(0.00216)
Metastatic Cancer	0.00325	(0.00172)
Solid Tumor without Metastasis	-0.00240**	(0.000818)
Rheumatoid Arthritis	-0.00503***	(0.000829)
Coagulation Deficiency	0.0189***	(0.00126)
Obesity	-0.00610***	(0.000365)
Weight Loss	0.00700***	(0.00187)
Fluid and Electrolyte Disorders	0.0222***	(0.000761)
Blood Loss Anemia	-0.00468***	(0.000985)
Deficiency Anemias	-0.0136***	(0.000461)
Alcohol Abuse	-0.00155	(0.00161)
Drug Abuse	-0.00401	(0.00298)
Psychoses	-0.00774***	(0.00112)
Depression	-0.00778***	(0.000506)
Physician Medical School Training		
30+ Ranked MD School	0.000879*	(0.000403)
Foreign Trained	0.000475	(0.000486)
Hospital Characteristics		
For-profit	0.000971	(0.000687)
Government	0.00231*	(0.000920)
Teaching	0.000448	(0.000625)
System	0.000649	(0.000504)
Cardiac Intensive Care	-2.09e-05	(0.000495)
Adult Cardiac Surgery	-0.000197	(0.000721)
Hospital Beds	1.32e-06	(1.09e-06)
RNs per Bed	-1.43e-05	(0.000464)
Medicaid Share of Admissions	0.0118***	(0.00302)
Year of PCI		
2002	-0.000704	(0.000400)
2003	0.00183***	(0.000471)
2004	0.00644***	(0.000796)
Observations	1,027,230	
R-squared	0.044	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.6.2—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Death 10 Days from PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	0.00201**	(0.000751)
Quartile 3	0.00230*	(0.00104)
Quartile 4	0.00270*	(0.00114)
Physician Annual PCI Volume		
In the Patient's Hospital	-9.74e-07	(3.67e-06)
In Other Hospitals	3.03e-06	(8.17e-06)
Hospital Annual PCI Volume	-1.42e-07	(8.67e-07)
Years as MD	-8.01e-05***	(2.09e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	0.000475	(0.000906)
2500 to 5000	0.00152	(0.00119)
5000 to 10000	0.00186	(0.00132)
0 PCI Hospitals in Market	0.000601	(0.00178)
Patient Characteristics		
Age 70 to 75	0.00228***	(0.000317)
Age 75 to 80	0.00645***	(0.000360)
Age 80 to 85	0.0117***	(0.000457)
Age 85 & Over	0.0215***	(0.000743)
Female	0.00618***	(0.000278)
African-American	-0.000131	(0.000672)
Asian	-0.000856	(0.00149)
Other Race	0.00116	(0.00131)
Hispanic	0.00127	(0.00131)
Procedure Characteristics		
AMI	0.0389***	(0.000546)
Outpatient	-0.00661***	(0.000545)
Emergency Dept.	0.000652	(0.000660)
Transfer	-0.000137	(0.000500)
Inpatient Urgent	0.000595	(0.000381)
Inpatient Emergent	0.00563***	(0.000658)
PTCA	0.0128***	(0.000596)
Both - PTCA & Stent	0.00430***	(0.000874)
Multivessel	0.00514***	(0.000671)
Right Coronary Vessel	-0.00340***	(0.000413)
Left Coronary Vessel	-0.00216***	(0.000423)
Left Descending Vessel	0.00228***	(0.000425)
Drug-Eluting Stent (Post April 2003)	-0.00965***	(0.000479)
Weekend	0.0125***	(0.000864)
Patient Comorbidities		
Congestive Heart Failure	-0.0139***	(0.000605)
Valvular Disease	-0.00450***	(0.000773)
Pulmonary Circulation Disorder	0.00323	(0.00215)
Peripheral Vascular Disease	-0.00182***	(0.000374)
Hypertension	-0.0155***	(0.000382)
Paralysis	0.00324*	(0.00128)
Other Neurological Disorders	0.000991	(0.000927)
Chronic Pulmonary Disease	0.00275***	(0.000380)
Diabetes Without Complication	0.000502	(0.000316)

Diabetes With Complications	2.94e-06	(0.000744)
Hypothyroidism	-0.00748***	(0.000407)
Renal Failure	0.0164***	(0.00108)
Liver Disease	0.00173	(0.00196)
Chronic Peptic Ulcer Disease	-0.00218	(0.00368)
HIV and AIDS	-0.0148***	(0.00299)
Lymphoma	0.00135	(0.00218)
Metastatic Cancer	0.00600***	(0.00174)
Solid Tumor without Metastasis	-0.000892	(0.000806)
Rheumatoid Arthritis	-0.00338***	(0.000888)
Coagulation Deficiency	0.0115***	(0.00107)
Obesity	-0.00575***	(0.000402)
Weight Loss	-0.00517***	(0.00156)
Fluid and Electrolyte Disorders	0.0194***	(0.000725)
Blood Loss Anemia	-0.00363***	(0.000939)
Deficiency Anemias	-0.0106***	(0.000436)
Alcohol Abuse	-0.000591	(0.00160)
Drug Abuse	-0.000310	(0.00332)
Psychoses	-0.00662***	(0.00118)
Depression	-0.00693***	(0.000555)
Physician Medical School Training		
30+ Ranked MD School	0.000971*	(0.000395)
Foreign Trained	0.000620	(0.000465)
Hospital Characteristics		
For-profit	0.000997	(0.000670)
Government	0.00246**	(0.000895)
Teaching	5.96e-05	(0.000611)
System	0.000543	(0.000506)
Cardiac Intensive Care	-0.000669	(0.000489)
Adult Cardiac Surgery	-0.000147	(0.000723)
Hospital Beds	1.00e-06	(1.06e-06)
RNs per Bed	-0.000458	(0.000484)
Medicaid Share of Admissions	0.00747**	(0.00282)
Year of PCI		
2002	-0.000301	(0.000393)
2003	0.00206***	(0.000466)
2004	0.00637***	(0.000788)
Observations	1,027,230	
R-squared	0.037	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.6.3—Relation between Corrected Multihospital Practice Quartile ($\widehat{MH}_{jt}$) and Death 30 Days from PCI, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widehat{MH}_{jt}$)		
Quartile 2	0.00224*	(0.000945)
Quartile 3	0.00245*	(0.00122)
Quartile 4	0.00264	(0.00135)
Physician Annual PCI Volume		
In the Patient's Hospital	3.99e-06	(4.60e-06)
In Other Hospitals	1.32e-05	(1.18e-05)
Hospital Annual PCI Volume	8.24e-07	(1.11e-06)
Years as MD	-0.000121***	(2.70e-05)
Hospital Market Structure ($\widehat{HHI}_{jt}$)		
1250 to 2500	-0.000269	(0.00116)
2500 to 5000	0.000826	(0.00145)
5000 to 10000	0.000331	(0.00157)
0 PCI Hospitals in Market	-0.00100	(0.00227)
Patient Characteristics		
Age 70 to 75	0.00330***	(0.000374)
Age 75 to 80	0.00866***	(0.000440)
Age 80 to 85	0.0162***	(0.000548)
Age 85 & Over	0.0290***	(0.000875)
Female	0.00649***	(0.000347)
African-American	0.000583	(0.000754)
Asian	-0.00124	(0.00176)
Other Race	0.00122	(0.00157)
Hispanic	0.00181	(0.00159)
Procedure Characteristics		
AMI	0.0498***	(0.000647)
Outpatient	-0.00929***	(0.000658)
Emergency Dept.	0.00144	(0.000768)
Transfer	0.00118*	(0.000600)
Inpatient Urgent	0.00108*	(0.000463)
Inpatient Emergent	0.00664***	(0.000771)
PTCA	0.0149***	(0.000694)
Both - PTCA & Stent	0.00524***	(0.000997)
Multivessel	0.00643***	(0.000761)
Right Coronary Vessel	-0.00467***	(0.000521)
Left Coronary Vessel	-0.00256***	(0.000534)
Left Descending Vessel	0.00352***	(0.000528)
Drug-Eluting Stent (Post April 2003)	-0.0115***	(0.000555)
Weekend	0.0146***	(0.000991)
Patient Comorbidities		
Congestive Heart Failure	-0.00887***	(0.000819)
Valvular Disease	-0.00537***	(0.00120)
Pulmonary Circulation Disorder	0.00477	(0.00299)
Peripheral Vascular Disease	-0.00271***	(0.000464)
Hypertension	-0.0219***	(0.000470)
Paralysis	0.00924***	(0.00180)
Other Neurological Disorders	0.00256*	(0.00117)
Chronic Pulmonary Disease	0.00643***	(0.000485)
Diabetes Without Complication	0.000263	(0.000390)

Diabetes With Complications	-0.000656	(0.000891)
Hypothyroidism	-0.0104***	(0.000476)
Renal Failure	0.0302***	(0.00146)
Liver Disease	0.00575*	(0.00256)
Chronic Peptic Ulcer Disease	-0.00353	(0.00444)
HIV and AIDS	-0.00731	(0.0141)
Lymphoma	0.00172	(0.00280)
Metastatic Cancer	0.0211***	(0.00247)
Solid Tumor without Metastasis	0.00128	(0.00115)
Rheumatoid Arthritis	-0.00487***	(0.00107)
Coagulation Deficiency	0.0247***	(0.00146)
Obesity	-0.00813***	(0.000503)
Weight Loss	0.0177***	(0.00269)
Fluid and Electrolyte Disorders	0.0296***	(0.000943)
Blood Loss Anemia	-0.00238	(0.00134)
Deficiency Anemias	-0.0138***	(0.000574)
Alcohol Abuse	-0.000866	(0.00203)
Drug Abuse	-0.00243	(0.00413)
Psychoses	-0.00534**	(0.00169)
Depression	-0.00996***	(0.000732)
Physician Medical School Training		
30+ Ranked MD School	0.00112*	(0.000484)
Foreign Trained	0.00116*	(0.000585)
Hospital Characteristics		
For-profit	0.000693	(0.000847)
Government	0.00260*	(0.00112)
Teaching	0.000911	(0.000764)
System	0.000421	(0.000594)
Cardiac Intensive Care	-0.000926	(0.000575)
Adult Cardiac Surgery	2.37e-05	(0.000883)
Hospital Beds	-6.39e-08	(1.28e-06)
RNs per Bed	-0.000713	(0.000569)
Medicaid Share of Admissions	0.0140***	(0.00342)
Year of PCI		
2002	-0.000780	(0.000482)
2003	0.00229***	(0.000540)
2004	0.00715***	(0.000984)
Observations	1,027,230	
R-squared	0.048	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.6.4—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Death 10 Days from Discharge, With HRR Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	6.30e-05	(0.000416)
Quartile 3	0.000180	(0.000584)
Quartile 4	-0.000158	(0.000596)
Physician Annual PCI Volume		
In the Patient's Hospital	1.90e-06	(1.50e-06)
In Other Hospitals	6.26e-06	(4.18e-06)
Hospital Annual PCI Volume	-2.84e-07	(3.79e-07)
Years as MD	-2.08e-05*	(1.04e-05)
Hospital Market Structure ($\widetilde{HHI}_{jt}$)		
1250 to 2500	-0.00116*	(0.000462)
2500 to 5000	-0.000811	(0.000641)
5000 to 10000	-0.000770	(0.000687)
0 PCI Hospitals in Market	0.000258	(0.000947)
Patient Characteristics		
Age 70 to 75	0.000443**	(0.000160)
Age 75 to 80	0.00119***	(0.000179)
Age 80 to 85	0.00277***	(0.000230)
Age 85 & Over	0.00518***	(0.000398)
Female	0.000450**	(0.000153)
African-American	0.000302	(0.000327)
Asian	-0.000574	(0.000613)
Other Race	-0.000743	(0.000567)
Hispanic	-1.15e-06	(0.000568)
Procedure Characteristics		
AMI	0.00767***	(0.000236)
Outpatient	-0.00110***	(0.000221)
Emergency Dept.	2.18e-05	(0.000295)
Transfer	0.00104***	(0.000268)
Inpatient Urgent	0.000347	(0.000185)
Inpatient Emergent	0.00131***	(0.000282)
PTCA	0.000869***	(0.000247)
Both - PTCA & Stent	0.000304	(0.000421)
Multivessel	0.00207***	(0.000335)
Right Coronary Vessel	-0.00131***	(0.000226)
Left Coronary Vessel	-0.000616**	(0.000220)
Left Descending Vessel	0.000585**	(0.000222)
Drug-Eluting Stent (Post April 2003)	-0.00139***	(0.000210)
Weekend	0.000610	(0.000353)
Patient Comorbidities		
Congestive Heart Failure	0.000808	(0.000435)
Valvular Disease	-0.00127*	(0.000538)
Pulmonary Circulation Disorder	0.000371	(0.00136)
Peripheral Vascular Disease	-0.000139	(0.000204)
Hypertension	-0.00300***	(0.000187)
Paralysis	0.00422***	(0.000857)
Other Neurological Disorders	0.00245***	(0.000637)
Chronic Pulmonary Disease	0.00197***	(0.000200)
Diabetes Without Complication	0.000325	(0.000168)

Diabetes With Complications	0.000119	(0.000408)
Hypothyroidism	-0.00124***	(0.000218)
Renal Failure	0.00571***	(0.000675)
Liver Disease	0.00206	(0.00122)
Chronic Peptic Ulcer Disease	-0.00255	(0.00166)
HIV and AIDS	0.00332	(0.0103)
Lymphoma	-0.000124	(0.00120)
Metastatic Cancer	0.00601***	(0.00136)
Solid Tumor without Metastasis	0.000890	(0.000544)
Rheumatoid Arthritis	-0.000466	(0.000541)
Coagulation Deficiency	0.00245***	(0.000564)
Obesity	-0.00126***	(0.000222)
Weight Loss	0.00603***	(0.00124)
Fluid and Electrolyte Disorders	0.00407***	(0.000308)
Blood Loss Anemia	-0.000362	(0.000609)
Deficiency Anemias	-0.00128***	(0.000293)
Alcohol Abuse	0.00159	(0.00108)
Drug Abuse	0.00186	(0.00255)
Psychoses	0.000797	(0.000918)
Depression	-0.00175***	(0.000322)
Physician Medical School Training		
30+ Ranked MD School	1.45e-05	(0.000184)
Foreign Trained	0.000385	(0.000207)
Hospital Characteristics		
For-profit	-0.000194	(0.000318)
Government	0.000659	(0.000519)
Teaching	0.000183	(0.000282)
System	-0.000237	(0.000212)
Cardiac Intensive Care	-0.000590**	(0.000224)
Adult Cardiac Surgery	0.000433	(0.000367)
Hospital Beds	2.09e-07	(4.50e-07)
RNs per Bed	-0.000260	(0.000219)
Medicaid Share of Admissions	0.00148	(0.00121)
Year of PCI		
2002	2.07e-05	(0.000194)
2003	0.000726***	(0.000207)
2004	0.000875*	(0.000392)
Observations	1,009,044	
R-squared	0.007	
Number of Fixed Effects	305	

Regression coefficients shown. Standard errors clustered at the HRR level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.7.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inpatient Death after PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.00166	(0.000884)
Quartile 3	0.00248*	(0.00110)
Quartile 4	0.00282*	(0.00119)
Physician Annual PCI Volume		
In the Patient's Hospital	-2.03e-06	(4.48e-06)
In Other Hospitals	2.26e-06	(8.71e-06)
Hospital Annual PCI Volume	3.42e-06	(2.05e-06)
Years as MD	-0.000104***	(2.18e-05)
Patient Characteristics		
Age 70 to 75	0.00280***	(0.000303)
Age 75 to 80	0.00708***	(0.000341)
Age 80 to 85	0.0120***	(0.000454)
Age 85 & Over	0.0203***	(0.000720)
Female	0.00660***	(0.000284)
African-American	-0.000142	(0.000701)
Asian	0.000104	(0.00146)
Other Race	0.00138	(0.00132)
Hispanic	0.000880	(0.00128)
Procedure Characteristics		
AMI	0.0407***	(0.000578)
Outpatient	-0.00918***	(0.000599)
Emergency Dept.	7.67e-05	(0.000699)
Transfer	-0.000892	(0.000499)
Inpatient Urgent	0.000864*	(0.000401)
Inpatient Emergent	0.00690***	(0.000710)
PTCA	0.0143***	(0.000598)
Both - PTCA & Stent	0.00478***	(0.000884)
Multivessel	0.00402***	(0.000691)
Right Coronary Vessel	-0.00310***	(0.000471)
Left Coronary Vessel	-0.00197***	(0.000472)
Left Descending Vessel	0.00237***	(0.000453)
Drug-Eluting Stent (Post April 2003)	-0.0107***	(0.000461)
Weekend	0.0146***	(0.000886)
Patient Comorbidities		
Congestive Heart Failure	-0.0123***	(0.000629)
Valvular Disease	-0.00356***	(0.000834)
Pulmonary Circulation Disorder	0.00205	(0.00216)
Peripheral Vascular Disease	-0.00378***	(0.000360)
Hypertension	-0.0196***	(0.000385)
Paralysis	-0.000323	(0.00127)
Other Neurological Disorders	-0.00132	(0.000906)
Chronic Pulmonary Disease	0.00262***	(0.000380)
Diabetes Without Complication	-0.000798*	(0.000310)
Diabetes With Complications	-0.000811	(0.000760)
Hypothyroidism	-0.00901***	(0.000382)
Renal Failure	0.0226***	(0.00118)
Liver Disease	0.00211	(0.00203)
Chronic Peptic Ulcer Disease	-0.00272	(0.00318)

HIV and AIDS	-0.0167***	(0.00345)
Lymphoma	-0.000555	(0.00215)
Metastatic Cancer	0.00318	(0.00171)
Solid Tumor without Metastasis	-0.00239**	(0.000817)
Rheumatoid Arthritis	-0.00497***	(0.000828)
Coagulation Deficiency	0.0188***	(0.00126)
Obesity	-0.00602***	(0.000366)
Weight Loss	0.00705***	(0.00187)
Fluid and Electrolyte Disorders	0.0221***	(0.000758)
Blood Loss Anemia	-0.00480***	(0.000987)
Deficiency Anemias	-0.0136***	(0.000463)
Alcohol Abuse	-0.00173	(0.00162)
Drug Abuse	-0.00438	(0.00297)
Psychoses	-0.00782***	(0.00112)
Depression	-0.00781***	(0.000505)
Physician Medical School Training		
30+ Ranked MD School	0.000647	(0.000419)
Foreign Trained	0.000213	(0.000505)
Year of PCI		
2002	-0.000476	(0.000401)
2003	0.00212***	(0.000485)
2004	0.00678***	(0.000624)
Observations	1,027,230	
R-squared	0.043	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.7.2—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Death 10 Days from PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.00171	(0.000873)
Quartile 3	0.00228*	(0.00110)
Quartile 4	0.00281*	(0.00117)
Physician Annual PCI Volume		
In the Patient's Hospital	2.86e-07	(3.81e-06)
In Other Hospitals	4.78e-06	(8.40e-06)
Hospital Annual PCI Volume	2.96e-06	(2.04e-06)
Years as MD	-9.08e-05***	(2.08e-05)
Patient Characteristics		
Age 70 to 75	0.00233***	(0.000316)
Age 75 to 80	0.00652***	(0.000360)
Age 80 to 85	0.0118***	(0.000457)
Age 85 & Over	0.0216***	(0.000738)
Female	0.00614***	(0.000279)
African-American	-0.000473	(0.000690)
Asian	-0.000828	(0.00150)
Other Race	0.00120	(0.00131)
Hispanic	0.00114	(0.00134)
Procedure Characteristics		
AMI	0.0387***	(0.000547)
Outpatient	-0.00625***	(0.000584)
Emergency Dept.	-0.000336	(0.000689)
Transfer	-0.000288	(0.000502)
Inpatient Urgent	0.000896*	(0.000427)
Inpatient Emergent	0.00664***	(0.000709)
PTCA	0.0130***	(0.000602)
Both - PTCA & Stent	0.00437***	(0.000887)
Multivessel	0.00546***	(0.000706)
Right Coronary Vessel	-0.00374***	(0.000450)
Left Coronary Vessel	-0.00252***	(0.000448)
Left Descending Vessel	0.00189***	(0.000443)
Drug-Eluting Stent (Post April 2003)	-0.00966***	(0.000486)
Weekend	0.0124***	(0.000863)
Patient Comorbidities		
Congestive Heart Failure	-0.0140***	(0.000604)
Valvular Disease	-0.00443***	(0.000780)
Pulmonary Circulation Disorder	0.00302	(0.00215)
Peripheral Vascular Disease	-0.00188***	(0.000378)
Hypertension	-0.0156***	(0.000378)
Paralysis	0.00319*	(0.00128)
Other Neurological Disorders	0.00100	(0.000922)
Chronic Pulmonary Disease	0.00270***	(0.000382)
Diabetes Without Complication	0.000487	(0.000317)
Diabetes With Complications	-2.21e-05	(0.000747)
Hypothyroidism	-0.00749***	(0.000405)
Renal Failure	0.0166***	(0.00108)
Liver Disease	0.00162	(0.00196)
Chronic Peptic Ulcer Disease	-0.00203	(0.00360)

HIV and AIDS	-0.0148***	(0.00314)
Lymphoma	0.00128	(0.00218)
Metastatic Cancer	0.00599***	(0.00174)
Solid Tumor without Metastasis	-0.000902	(0.000806)
Rheumatoid Arthritis	-0.00332***	(0.000887)
Coagulation Deficiency	0.0115***	(0.00108)
Obesity	-0.00568***	(0.000401)
Weight Loss	-0.00516***	(0.00157)
Fluid and Electrolyte Disorders	0.0194***	(0.000721)
Blood Loss Anemia	-0.00372***	(0.000941)
Deficiency Anemias	-0.0106***	(0.000438)
Alcohol Abuse	-0.000697	(0.00162)
Drug Abuse	-0.000682	(0.00333)
Psychoses	-0.00677***	(0.00118)
Depression	-0.00696***	(0.000551)
Physician Medical School Training		
30+ Ranked MD School	0.000783	(0.000415)
Foreign Trained	0.000552	(0.000480)
Year of PCI		
2002	-0.000179	(0.000400)
2003	0.00212***	(0.000488)
2004	0.00636***	(0.000629)
Observations	1,027,230	
R-squared	0.036	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.7.3—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Death 30 Days from PCI, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.00215*	(0.00107)
Quartile 3	0.00327**	(0.00127)
Quartile 4	0.00351**	(0.00135)
Physician Annual PCI Volume		
In the Patient's Hospital	2.59e-06	(4.90e-06)
In Other Hospitals	1.15e-05	(1.13e-05)
Hospital Annual PCI Volume	5.05e-06	(2.75e-06)
Years as MD	-0.000131***	(2.70e-05)
Patient Characteristics		
Age 70 to 75	0.00335***	(0.000373)
Age 75 to 80	0.00874***	(0.000442)
Age 80 to 85	0.0163***	(0.000547)
Age 85 & Over	0.0291***	(0.000872)
Female	0.00644***	(0.000349)
African-American	1.39e-05	(0.000776)
Asian	-0.00142	(0.00176)
Other Race	0.00119	(0.00156)
Hispanic	0.00123	(0.00158)
Procedure Characteristics		
AMI	0.0497***	(0.000650)
Outpatient	-0.00901***	(0.000705)
Emergency Dept.	0.000314	(0.000807)
Transfer	0.000977	(0.000610)
Inpatient Urgent	0.00153**	(0.000507)
Inpatient Emergent	0.00780***	(0.000825)
PTCA	0.0151***	(0.000698)
Both - PTCA & Stent	0.00523***	(0.00101)
Multivessel	0.00700***	(0.000794)
Right Coronary Vessel	-0.00522***	(0.000563)
Left Coronary Vessel	-0.00314***	(0.000558)
Left Descending Vessel	0.00289***	(0.000549)
Drug-Eluting Stent (Post April 2003)	-0.0116***	(0.000565)
Weekend	0.0145***	(0.000991)
Patient Comorbidities		
Congestive Heart Failure	-0.00904***	(0.000816)
Valvular Disease	-0.00532***	(0.00121)
Pulmonary Circulation Disorder	0.00456	(0.00299)
Peripheral Vascular Disease	-0.00282***	(0.000464)
Hypertension	-0.0220***	(0.000467)
Paralysis	0.00916***	(0.00180)
Other Neurological Disorders	0.00251*	(0.00116)
Chronic Pulmonary Disease	0.00637***	(0.000486)
Diabetes Without Complication	0.000241	(0.000391)
Diabetes With Complications	-0.000705	(0.000893)
Hypothyroidism	-0.0104***	(0.000475)
Renal Failure	0.0303***	(0.00146)
Liver Disease	0.00560*	(0.00256)
Chronic Peptic Ulcer Disease	-0.00332	(0.00438)

HIV and AIDS	-0.00795	(0.0142)
Lymphoma	0.00159	(0.00278)
Metastatic Cancer	0.0210***	(0.00247)
Solid Tumor without Metastasis	0.00126	(0.00115)
Rheumatoid Arthritis	-0.00479***	(0.00107)
Coagulation Deficiency	0.0246***	(0.00146)
Obesity	-0.00809***	(0.000504)
Weight Loss	0.0177***	(0.00269)
Fluid and Electrolyte Disorders	0.0295***	(0.000936)
Blood Loss Anemia	-0.00247	(0.00134)
Deficiency Anemias	-0.0138***	(0.000577)
Alcohol Abuse	-0.00112	(0.00204)
Drug Abuse	-0.00295	(0.00414)
Psychoses	-0.00556***	(0.00168)
Depression	-0.0100***	(0.000731)
Physician Medical School Training		
30+ Ranked MD School	0.000756	(0.000512)
Foreign Trained	0.000843	(0.000586)
Year of PCI		
2002	-0.000583	(0.000486)
2003	0.00238***	(0.000572)
2004	0.00739***	(0.000761)
Observations	1,027,230	
R-squared	0.047	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.7.7.4—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Death 10 Days from Discharge, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.000191	(0.000437)
Quartile 3	0.000515	(0.000553)
Quartile 4	0.000392	(0.000613)
Physician Annual PCI Volume		
In the Patient's Hospital	2.04e-06	(1.62e-06)
In Other Hospitals	5.79e-06	(4.80e-06)
Hospital Annual PCI Volume	-1.01e-07	(1.32e-06)
Years as MD	-1.73e-05	(1.06e-05)
Patient Characteristics		
Age 70 to 75	0.000441**	(0.000161)
Age 75 to 80	0.00119***	(0.000180)
Age 80 to 85	0.00276***	(0.000229)
Age 85 & Over	0.00517***	(0.000399)
Female	0.000431**	(0.000154)
African-American	0.000208	(0.000340)
Asian	-0.000679	(0.000650)
Other Race	-0.000743	(0.000568)
Hispanic	-9.36e-05	(0.000553)
Procedure Characteristics		
AMI	0.00763***	(0.000235)
Outpatient	-0.00122***	(0.000236)
Emergency Dept.	-0.000120	(0.000311)
Transfer	0.000982***	(0.000276)
Inpatient Urgent	0.000429*	(0.000211)
Inpatient Emergent	0.00138***	(0.000307)
PTCA	0.000915***	(0.000247)
Both - PTCA & Stent	0.000356	(0.000424)
Multivessel	0.00211***	(0.000358)
Right Coronary Vessel	-0.00136***	(0.000243)
Left Coronary Vessel	-0.000676**	(0.000243)
Left Descending Vessel	0.000520*	(0.000242)
Drug-Eluting Stent (Post April 2003)	-0.00136***	(0.000212)
Weekend	0.000548	(0.000355)
Patient Comorbidities		
Congestive Heart Failure	0.000762	(0.000433)
Valvular Disease	-0.00125*	(0.000536)
Pulmonary Circulation Disorder	0.000438	(0.00136)
Peripheral Vascular Disease	-0.000161	(0.000203)
Hypertension	-0.00303***	(0.000188)
Paralysis	0.00424***	(0.000860)
Other Neurological Disorders	0.00244***	(0.000638)
Chronic Pulmonary Disease	0.00195***	(0.000201)
Diabetes Without Complication	0.000320	(0.000169)
Diabetes With Complications	0.000132	(0.000407)
Hypothyroidism	-0.00122***	(0.000218)
Renal Failure	0.00574***	(0.000674)
Liver Disease	0.00199	(0.00122)
Chronic Peptic Ulcer Disease	-0.00253	(0.00166)

HIV and AIDS	0.00353	(0.0103)
Lymphoma	-9.46e-05	(0.00120)
Metastatic Cancer	0.00600***	(0.00136)
Solid Tumor without Metastasis	0.000862	(0.000545)
Rheumatoid Arthritis	-0.000452	(0.000540)
Coagulation Deficiency	0.00246***	(0.000565)
Obesity	-0.00126***	(0.000224)
Weight Loss	0.00601***	(0.00124)
Fluid and Electrolyte Disorders	0.00408***	(0.000307)
Blood Loss Anemia	-0.000366	(0.000610)
Deficiency Anemias	-0.00129***	(0.000292)
Alcohol Abuse	0.00158	(0.00108)
Drug Abuse	0.00167	(0.00255)
Psychoses	0.000692	(0.000923)
Depression	-0.00174***	(0.000321)
Physician Medical School Training		
30+ Ranked MD School	-8.86e-05	(0.000203)
Foreign Trained	0.000323	(0.000231)
Year of PCI		
2002	5.68e-05	(0.000195)
2003	0.000705**	(0.000220)
2004	0.00118***	(0.000290)
Observations	1,009,044	
R-squared	0.006	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.8.1.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inpatient Death after PCI for Outpatient or Referral Patients ("selected physician"), With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.000405	(0.000772)
Quartile 3	0.00147	(0.000912)
Quartile 4	0.00117	(0.00103)
Physician Annual PCI Volume		
In the Patient's Hospital	-2.98e-06	(3.93e-06)
In Other Hospitals	4.16e-06	(8.55e-06)
Hospital Annual PCI Volume	3.27e-06*	(1.60e-06)
Years as MD	-6.45e-05**	(2.01e-05)
Patient Characteristics		
Age 70 to 75	0.00133***	(0.000264)
Age 75 to 80	0.00290***	(0.000289)
Age 80 to 85	0.00521***	(0.000380)
Age 85 & Over	0.0101***	(0.000725)
Female	0.00364***	(0.000272)
African-American	-0.000274	(0.000597)
Asian	-0.000690	(0.00120)
Other Race	0.000926	(0.00116)
Hispanic	-0.00152	(0.00115)
Procedure Characteristics		
AMI	0.0427***	(0.000953)
Outpatient	-0.00298***	(0.000551)
Inpatient Urgent	0.000965*	(0.000395)
Inpatient Emergent	0.00591***	(0.000922)
PTCA	0.00658***	(0.000532)
Both - PTCA & Stent	0.00239***	(0.000726)
Multivessel	0.00185**	(0.000618)
Right Coronary Vessel	-0.00122**	(0.000411)
Left Coronary Vessel	-0.000237	(0.000425)
Left Descending Vessel	0.00142***	(0.000400)
Drug-Eluting Stent (Post April 2003)	-0.00424***	(0.000385)
Weekend	0.00827***	(0.000988)
Patient Comorbidities		
Congestive Heart Failure	-0.00589***	(0.000670)
Valvular Disease	-0.00159	(0.000812)
Pulmonary Circulation Disorder	0.00112	(0.00207)
Peripheral Vascular Disease	-0.00154***	(0.000287)
Hypertension	-0.00857***	(0.000348)
Paralysis	-0.00106	(0.00122)
Other Neurological Disorders	-0.000149	(0.000965)
Chronic Pulmonary Disease	0.00154***	(0.000351)
Diabetes Without Complication	-0.000874***	(0.000262)
Diabetes With Complications	8.93e-06	(0.000801)
Hypothyroidism	-0.00376***	(0.000368)
Renal Failure	0.0153***	(0.00128)
Liver Disease	0.00119	(0.00210)
Chronic Peptic Ulcer Disease	-0.00385	(0.00261)

HIV and AIDS	-0.00479*	(0.00218)
Lymphoma	0.00209	(0.00230)
Metastatic Cancer	0.00231	(0.00175)
Solid Tumor without Metastasis	-0.00205**	(0.000733)
Rheumatoid Arthritis	-0.00313***	(0.000836)
Coagulation Deficiency	0.0158***	(0.00144)
Obesity	-0.00303***	(0.000343)
Weight Loss	0.00452*	(0.00224)
Fluid and Electrolyte Disorders	0.0131***	(0.000745)
Blood Loss Anemia	-0.00139	(0.00114)
Deficiency Anemias	-0.00670***	(0.000434)
Alcohol Abuse	-0.00118	(0.00166)
Drug Abuse	-0.000810	(0.00397)
Psychoses	-0.00597***	(0.00134)
Depression	-0.00421***	(0.000520)
Physician Medical School Training		
30+ Ranked MD School	0.000241	(0.000338)
Foreign Trained	7.65e-05	(0.000398)
Year of PCI		
2002	-0.000222	(0.000377)
2003	0.00105*	(0.000440)
2004	0.00278***	(0.000533)
Observations	611,286	
R-squared	0.033	
Number of Fixed Effects	1,271	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.8.1.2—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inpatient Death after PCI for ED or Transfer Patients ("did not select physician"), With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.00403*	(0.00193)
Quartile 3	0.00502*	(0.00219)
Quartile 4	0.00536*	(0.00245)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.08e-06	(8.91e-06)
In Other Hospitals	-1.05e-06	(1.78e-05)
Hospital Annual PCI Volume	4.40e-06	(4.50e-06)
Years as MD	-0.000130**	(4.57e-05)
Patient Characteristics		
Age 70 to 75	0.00543***	(0.000650)
Age 75 to 80	0.0140***	(0.000767)
Age 80 to 85	0.0221***	(0.000902)
Age 85 & Over	0.0325***	(0.00127)
Female	0.0109***	(0.000601)
African-American	0.000638	(0.00131)
Asian	0.00435	(0.00360)
Other Race	0.00271	(0.00274)
Hispanic	0.00527	(0.00282)
Procedure Characteristics		
AMI	0.0380***	(0.000672)
Emergency Dept.	-0.00269**	(0.000992)
Inpatient Urgent	0.00304*	(0.00121)
Inpatient Emergent	0.0109***	(0.00137)
PTCA	0.0259***	(0.00122)
Both - PTCA & Stent	0.00877***	(0.00186)
Multivessel	0.00737***	(0.00145)
Right Coronary Vessel	-0.00591***	(0.000908)
Left Coronary Vessel	-0.00452***	(0.00102)
Left Descending Vessel	0.00354***	(0.00103)
Drug-Eluting Stent (Post April 2003)	-0.0212***	(0.000911)
Weekend	0.0186***	(0.00123)
Patient Comorbidities		
Congestive Heart Failure	-0.0181***	(0.00107)
Valvular Disease	-0.00579***	(0.00153)
Pulmonary Circulation Disorder	0.00313	(0.00373)
Peripheral Vascular Disease	-0.00703***	(0.000735)
Hypertension	-0.0365***	(0.000822)
Paralysis	0.000870	(0.00198)
Other Neurological Disorders	-0.00271	(0.00157)
Chronic Pulmonary Disease	0.00330***	(0.000671)
Diabetes Without Complication	-0.00134*	(0.000605)
Diabetes With Complications	-0.000686	(0.00121)
Hypothyroidism	-0.0153***	(0.000700)
Renal Failure	0.0300***	(0.00188)
Liver Disease	0.00362	(0.00333)
Chronic Peptic Ulcer Disease	-0.00188	(0.00681)
HIV and AIDS	-0.0237***	(0.00537)

Lymphoma	-0.00287	(0.00394)
Metastatic Cancer	0.00407	(0.00314)
Solid Tumor without Metastasis	-0.00278	(0.00156)
Rheumatoid Arthritis	-0.00670***	(0.00148)
Coagulation Deficiency	0.0209***	(0.00178)
Obesity	-0.00959***	(0.000677)
Weight Loss	0.00843**	(0.00307)
Fluid and Electrolyte Disorders	0.0290***	(0.00112)
Blood Loss Anemia	-0.00856***	(0.00156)
Deficiency Anemias	-0.0204***	(0.000768)
Alcohol Abuse	-0.00185	(0.00255)
Drug Abuse	-0.00514	(0.00460)
Psychoses	-0.00878***	(0.00181)
Depression	-0.0106***	(0.000812)
Physician Medical School Training		
30+ Ranked MD School	0.00115	(0.000814)
Foreign Trained	0.000155	(0.00106)
Year of PCI		
2002	-0.000809	(0.000867)
2003	0.00339***	(0.000949)
2004	0.0129***	(0.00123)
Observations	415,944	
R-squared	0.044	
Number of Fixed Effects	1,271	

Regression coefficients shown. Standard errors clustered at the hospital level.

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

Table A.8.2.1—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inpatient Death after PCI for Outpatient or Referral Patients ("selected physician"), With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.000582	(0.00108)
Quartile 3	0.00166	(0.00117)
Quartile 4	0.00135	(0.00130)
Physician Annual PCI Volume		
In the Patient's Hospital	-6.00e-07	(3.74e-06)
In Other Hospitals	4.13e-06	(1.02e-05)
Hospital Annual PCI Volume	5.46e-06*	(2.23e-06)
Years as MD	-8.86e-05***	(2.34e-05)
Patient Characteristics		
Age 70 to 75	0.00150***	(0.000318)
Age 75 to 80	0.00373***	(0.000358)
Age 80 to 85	0.00838***	(0.000501)
Age 85 & Over	0.0154***	(0.000863)
Female	0.00339***	(0.000342)
African-American	0.000241	(0.000737)
Asian	-0.000777	(0.00166)
Other Race	0.000719	(0.00135)
Hispanic	-0.00119	(0.00154)
Procedure Characteristics		
AMI	0.0534***	(0.00108)
Outpatient	-0.00268***	(0.000682)
Inpatient Urgent	0.00135**	(0.000507)
Inpatient Emergent	0.00611***	(0.00106)
PTCA	0.00714***	(0.000639)
Both - PTCA & Stent	0.00261**	(0.000898)
Multivessel	0.00340***	(0.000771)
Right Coronary Vessel	-0.00231***	(0.000535)
Left Coronary Vessel	-0.000566	(0.000547)
Left Descending Vessel	0.00190***	(0.000513)
Drug-Eluting Stent (Post April 2003)	-0.00483***	(0.000498)
Weekend	0.00916***	(0.00110)
Patient Comorbidities		
Congestive Heart Failure	-0.00245*	(0.000964)
Valvular Disease	-0.00222	(0.00119)
Pulmonary Circulation Disorder	-0.00212	(0.00298)
Peripheral Vascular Disease	-0.000758	(0.000402)
Hypertension	-0.0101***	(0.000428)
Paralysis	0.00690***	(0.00182)
Other Neurological Disorders	0.00207	(0.00135)
Chronic Pulmonary Disease	0.00443***	(0.000477)
Diabetes Without Complication	0.000168	(0.000357)
Diabetes With Complications	-0.000470	(0.00101)
Hypothyroidism	-0.00438***	(0.000495)
Renal Failure	0.0211***	(0.00167)
Liver Disease	0.00237	(0.00259)
Chronic Peptic Ulcer Disease	-0.00401	(0.00432)
HIV and AIDS	-0.0100***	(0.00301)

Lymphoma	0.00193	(0.00283)
Metastatic Cancer	0.00924***	(0.00267)
Solid Tumor without Metastasis	0.00214	(0.00115)
Rheumatoid Arthritis	-0.00331**	(0.00114)
Coagulation Deficiency	0.0221***	(0.00171)
Obesity	-0.00440***	(0.000469)
Weight Loss	0.0134***	(0.00309)
Fluid and Electrolyte Disorders	0.0189***	(0.000910)
Blood Loss Anemia	0.00130	(0.00145)
Deficiency Anemias	-0.00681***	(0.000601)
Alcohol Abuse	-0.00211	(0.00209)
Drug Abuse	0.00286	(0.00596)
Psychoses	-0.00508*	(0.00212)
Depression	-0.00539***	(0.000716)
Physician Medical School Training		
30+ Ranked MD School	0.000428	(0.000404)
Foreign Trained	0.000454	(0.000492)
Year of PCI		
2002	-0.000652	(0.000474)
2003	0.000701	(0.000525)
2004	0.00257***	(0.000656)
Observations	611,286	
R-squared	0.035	
Number of Fixed Effects	1,271	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.8.2.2—Relation between Corrected Multihospital Practice Quartile ($\widetilde{MH}_{jt}$) and Inpatient Death after PCI for ED or Transfer Patients (“did not select physician”), With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Multihospital Physician ($\widetilde{MH}_{jt}$)		
Quartile 2	0.00457*	(0.00214)
Quartile 3	0.00636*	(0.00248)
Quartile 4	0.00587*	(0.00275)
Physician Annual PCI Volume		
In the Patient’s Hospital	9.89e-06	(1.05e-05)
In Other Hospitals	2.40e-05	(2.14e-05)
Hospital Annual PCI Volume	4.49e-06	(5.45e-06)
Years as MD	-0.000162**	(5.11e-05)
Patient Characteristics		
Age 70 to 75	0.00664***	(0.000763)
Age 75 to 80	0.0170***	(0.000896)
Age 80 to 85	0.0282***	(0.00109)
Age 85 & Over	0.0452***	(0.00152)
Female	0.0109***	(0.000663)
African-American	0.000462	(0.00153)
Asian	-0.000560	(0.00386)
Other Race	0.00249	(0.00312)
Hispanic	0.00541	(0.00340)
Procedure Characteristics		
AMI	0.0461***	(0.000810)
Emergency Dept.	-0.00483***	(0.00114)
Inpatient Urgent	0.00353*	(0.00138)
Inpatient Emergent	0.0125***	(0.00162)
PTCA	0.0269***	(0.00133)
Both - PTCA & Stent	0.00949***	(0.00210)
Multivessel	0.0126***	(0.00169)
Right Coronary Vessel	-0.00955***	(0.00107)
Left Coronary Vessel	-0.00702***	(0.00124)
Left Descending Vessel	0.00400***	(0.00119)
Drug-Eluting Stent (Post April 2003)	-0.0227***	(0.00109)
Weekend	0.0175***	(0.00134)
Patient Comorbidities		
Congestive Heart Failure	-0.0154***	(0.00136)
Valvular Disease	-0.00864***	(0.00207)
Pulmonary Circulation Disorder	0.0122*	(0.00518)
Peripheral Vascular Disease	-0.00569***	(0.000891)
Hypertension	-0.0402***	(0.000974)
Paralysis	0.0116***	(0.00262)
Other Neurological Disorders	0.00247	(0.00195)
Chronic Pulmonary Disease	0.00805***	(0.000824)
Diabetes Without Complication	-0.000331	(0.000711)
Diabetes With Complications	0.000153	(0.00143)
Hypothyroidism	-0.0176***	(0.000857)
Renal Failure	0.0395***	(0.00210)
Liver Disease	0.00983*	(0.00390)
Chronic Peptic Ulcer Disease	-0.00272	(0.00828)
HIV and AIDS	-0.00282	(0.0270)

Lymphoma	0.00207	(0.00507)
Metastatic Cancer	0.0335***	(0.00484)
Solid Tumor without Metastasis	0.000415	(0.00197)
Rheumatoid Arthritis	-0.00605**	(0.00197)
Coagulation Deficiency	0.0262***	(0.00200)
Obesity	-0.0124***	(0.000890)
Weight Loss	0.0202***	(0.00408)
Fluid and Electrolyte Disorders	0.0376***	(0.00132)
Blood Loss Anemia	-0.00673**	(0.00208)
Deficiency Anemias	-0.0206***	(0.000990)
Alcohol Abuse	3.30e-05	(0.00324)
Drug Abuse	-0.00533	(0.00622)
Psychoses	-0.00545*	(0.00250)
Depression	-0.0138***	(0.00110)
Physician Medical School Training		
30+ Ranked MD School	0.00112	(0.000965)
Foreign Trained	0.00111	(0.00118)
Year of PCI		
2002	-0.000391	(0.000966)
2003	0.00460***	(0.00107)
2004	0.0148***	(0.00140)
Observations	415,944	
R-squared	0.047	
Number of Fixed Effects	1,271	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.8.3— Relation between 10 Day Mortality after PCI and Physician Group—Uncorrected Multihospital Status (MH_{jt}) and More than 1 Hospital Days ($sameday\ MH_{ij}$)—Interacted with the Physician's PCI Volume in the Hospital, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Physician Group		
Solo-Hospital Physician (ref)	--	--
Multihospital Physician in 1 Hospital that Day	0.000612	(0.000505)
Multihospital Physician in More than 1 Hospital that Day	0.00369*	(0.00150)
Physician Annual PCI Volume		
In the Patient's Hospital	4.45e-06	(4.37e-06)
In Other Hospitals	1.79e-06	(8.05e-06)
Hospital Annual PCI Volume	2.94e-06	(2.17e-06)
Years as MD	-9.08e-05***	(2.11e-05)
Interaction between Physician Annual PCI Volume In the Patient's Hospital and		
Solo-Hospital Physician (ref)	--	--
Multihospital Physician in 1 Hospital that Day	-9.30e-06	(5.15e-06)
Multihospital Physician in More than 1 Hospital that Day	-5.02e-05**	(1.71e-05)
Patient Characteristics		
Age 70 to 75	0.00233***	(0.000301)
Age 75 to 80	0.00652***	(0.000364)
Age 80 to 85	0.0118***	(0.000471)
Age 85 & Over	0.0215***	(0.000769)
Female	0.00614***	(0.000286)
African-American	-0.000470	(0.000661)
Asian	-0.000810	(0.00134)
Other Race	0.00120	(0.00127)
Hispanic	0.00114	(0.00117)
Procedure Characteristics		
AMI	0.0387***	(0.000593)
Outpatient	-0.00625***	(0.000594)
Emergency Dept.	-0.000330	(0.000685)
Transfer	-0.000302	(0.000495)
Inpatient Urgent	0.000901*	(0.000410)
Inpatient Emergent	0.00665***	(0.000707)
PTCA	0.0130***	(0.000616)
Both - PTCA & Stent	0.00436***	(0.000862)
Multivessel	0.00538***	(0.000696)
Right Coronary Vessel	-0.00366***	(0.000458)
Left Coronary Vessel	-0.00244***	(0.000458)
Left Descending Vessel	0.00196***	(0.000466)
Drug-Eluting Stent (Post April 2003)	-0.00967***	(0.000460)
Weekend	0.0124***	(0.000853)
Patient Comorbidities		
Congestive Heart Failure	-0.0140***	(0.000614)
Valvular Disease	-0.00443***	(0.000765)
Pulmonary Circulation Disorder	0.00303	(0.00220)
Peripheral Vascular Disease	-0.00188***	(0.000359)

Hypertension	-0.0156***	(0.000396)
Paralysis	0.00319*	(0.00129)
Other Neurological Disorders	0.001000	(0.000964)
Chronic Pulmonary Disease	0.00269***	(0.000366)
Diabetes Without Complication	0.000488	(0.000290)
Diabetes With Complications	-3.07e-05	(0.000746)
Hypothyroidism	-0.00749***	(0.000394)
Renal Failure	0.0166***	(0.00103)
Liver Disease	0.00162	(0.00200)
Chronic Peptic Ulcer Disease	-0.00203	(0.00338)
HIV and AIDS	-0.0147***	(0.00298)
Lymphoma	0.00128	(0.00222)
Metastatic Cancer	0.00599***	(0.00175)
Solid Tumor without Metastasis	-0.000901	(0.000790)
Rheumatoid Arthritis	-0.00332***	(0.000896)
Coagulation Deficiency	0.0115***	(0.00109)
Obesity	-0.00568***	(0.000390)
Weight Loss	-0.00516**	(0.00158)
Fluid and Electrolyte Disorders	0.0194***	(0.000711)
Blood Loss Anemia	-0.00371***	(0.000964)
Deficiency Anemias	-0.0106***	(0.000457)
Alcohol Abuse	-0.000693	(0.00157)
Drug Abuse	-0.000676	(0.00354)
Psychoses	-0.00678***	(0.00131)
Depression	-0.00696***	(0.000526)
Physician Medical School Training		
30+ Ranked MD School	0.000760	(0.000432)
Foreign Trained	0.000506	(0.000465)
Year of PCI		
2002	-0.000111	(0.000402)
2003	0.00220***	(0.000452)
2004	0.00642***	(0.000589)
Observations	1,027,230	
R-squared	0.036	
Number of Fixed Effects	1,276	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05

Table A.8.4— Relation between 10 Day Mortality after PCI and Same-Day Multihospital Practice in the Physician's Secondary Hospitals Compared to their Primary Hospital, With Hospital Fixed Effects

VARIABLES	(1) coef	(2) se
Same-Day Multihospital	-0.00112	(0.00118)
Hospital Status		
Primary (ref)		
Secondary	0.00132	(0.000777)
Interaction between Same-Day Multihospital and Secondary Hospital Status	0.00415*	(0.00199)
Physician Annual PCI Volume		
In the Patient's Hospital	-1.53e-06	(4.97e-06)
In Other Hospitals	-6.61e-06	(9.53e-06)
Hospital Annual PCI Volume	7.56e-06*	(3.33e-06)
Years as MD	-9.65e-05**	(3.35e-05)
Patient Characteristics		
Age 70 to 75	0.00225***	(0.000450)
Age 75 to 80	0.00676***	(0.000561)
Age 80 to 85	0.0116***	(0.000691)
Age 85 & Over	0.0233***	(0.00122)
Female	0.00590***	(0.000457)
African-American	-0.00169	(0.000998)
Asian	0.00221	(0.00222)
Other Race	0.00179	(0.00212)
Hispanic	0.00114	(0.00169)
Procedure Characteristics		
AMI	0.0400***	(0.000853)
Outpatient	-0.00709***	(0.000834)
Emergency Dept.	-0.00102	(0.00108)
Transfer	0.000394	(0.000811)
Inpatient Urgent	0.000933	(0.000627)
Inpatient Emergent	0.00756***	(0.00108)
PTCA	0.0135***	(0.000895)
Both - PTCA & Stent	0.00338**	(0.00124)
Multivessel	0.00565***	(0.00105)
Right Coronary Vessel	-0.00322***	(0.000707)
Left Coronary Vessel	-0.00264***	(0.000696)
Left Descending Vessel	0.00171*	(0.000733)
Drug-Eluting Stent (Post April 2003)	-0.00926***	(0.000658)
Weekend	0.0116***	(0.00122)
Patient Comorbidities		
Congestive Heart Failure	-0.0149***	(0.000925)
Valvular Disease	-0.00521***	(0.00122)
Pulmonary Circulation Disorder	0.00578	(0.00359)
Peripheral Vascular Disease	-0.00213***	(0.000531)
Hypertension	-0.0161***	(0.000579)
Paralysis	0.00525**	(0.00201)
Other Neurological Disorders	0.000744	(0.00137)
Chronic Pulmonary Disease	0.00337***	(0.000602)
Diabetes Without Complication	0.000347	(0.000443)
Diabetes With Complications	0.000614	(0.00106)
Hypothyroidism	-0.00679***	(0.000633)

Renal Failure	0.0163***	(0.00157)
Liver Disease	0.000791	(0.00333)
Chronic Peptic Ulcer Disease	-0.00572	(0.00483)
HIV and AIDS	-0.00802	(0.00490)
Lymphoma	0.00165	(0.00351)
Metastatic Cancer	0.00404	(0.00264)
Solid Tumor without Metastasis	-0.000107	(0.00125)
Rheumatoid Arthritis	-0.00288*	(0.00141)
Coagulation Deficiency	0.0117***	(0.00163)
Obesity	-0.00549***	(0.000627)
Weight Loss	-0.00740**	(0.00229)
Fluid and Electrolyte Disorders	0.0196***	(0.00105)
Blood Loss Anemia	-0.00187	(0.00150)
Deficiency Anemias	-0.0110***	(0.000696)
Alcohol Abuse	0.000628	(0.00258)
Drug Abuse	-0.00282	(0.00513)
Psychoses	-0.00307	(0.00214)
Depression	-0.00714***	(0.000841)
Physician Medical School Training		
30+ Ranked MD School	0.000346	(0.000677)
Foreign Trained	-8.63e-05	(0.000709)
Year of PCI		
2002	-0.00103	(0.000639)
2003	0.000794	(0.000704)
2004	0.00520***	(0.000886)
Observations	433,591	
R-squared	0.037	
Number of Fixed Effects	1,123	

Regression coefficients shown. Standard errors clustered at the hospital level.
*** p<0.001, ** p<0.01, * p<0.05