OC12028

Dr. Lara K. Gardner
Dr. Sang Lee
Southeastern Louisiana University

Technology Adoption in Healthcare: Physicians' Incentives and Decisions
Work-in-Progress

I. Introduction

An important goal of the healthcare system is to increase efficiency in the delivery of services while simultaneously improving quality of care. An understanding of how physician performance influences healthcare expenditures and quality of care, and how to motivate performance that improves efficiency and quality is crucial in achieving these policy goals. Although compensation for physician and clinical services has represented approximately 21% of national healthcare expenditures each year since 2000 (CMS 2010), some researchers argue that physicians are responsible for decisions that govern the way as much as 90% of healthcare expenditures are used (Eisenberg 2002). Physicians influence healthcare expenditures and quality not only through the services they provide directly, but also indirectly via the tests they order, specialists to whom they refer, drugs they prescribe, and hospitals where they admit patients.

This study addresses the critical need for rigorous econometric research on the relationships between physician human capital and patients' quality of care by examining the question of whether physician characteristics affect patient outcomes and resource use within hospitals, and how those effects occur. In particular, we will examine how physicians' quality of medical school and residency training, board certification, years of experience, and prior volume of procedures are related to patients' mortality rates, total hospital charges, length of stay, and the adoption of a new technology. This paper is based on panel designs of data for inpatients treated in all general and teaching hospitals in the state of Florida from 2000 – 2005. We combine three data sets that can be linked by hospital and physician identifiers: one comprises patients' characteristics, insurance status, billing and discharge information, the second contains hospital characteristics, and the third data set consists of demographic, licensing, and training data on physicians. We will focus the study on inpatients treated for procedures classified under the major diagnostic category (MDC) of 'Diseases and Disorders of the Circulatory System,' which are procedures related to the heart. By focusing on one medical specialty, we avoid potential estimation bias that could result from correlations between the outcomes within a disease category and average physician characteristics across specialties. Our empirical goal is to determine how physician characteristics are related to patients' outcomes, resource use, and the adoption of a new medical technology.

Our findings have implications for studies examining adverse outcomes for underserved populations as well as medical schools and employers of physicians. If physician schooling plays a significant role in explaining outcomes for patients, further study of best practices in medical schools or dissemination of educational practices is warranted. Patients, hospitals and insurance companies all rely on schooling, board certification and experience as indicators of physician quality. In addition, payments to physicians, hospital credentialing, and selection by insurance programs all depend on such characteristics. An understanding of whether these physician attributes actually improve the delivery of healthcare services or merely increase costs is crucial in the delivery of quality and cost effective health services. Through this study we hope to improve our understanding of which physician attributes contribute to higher quality healthcare (outcomes), how physicians achieve improvements in outcomes (technology, practice patterns) and whether this improvement is achieved in a cost effective manner (length of stay, charges).

II. Background

An extensive body of literature demonstrates that there is a great deal of variation in patient outcomes and resource use across physicians that is unexplained even after controlling for patients' characteristics and the physical capital of providers (Epstein and Nicholson 2009; Wennberg 2002; Roos 1984; Eisenberg and Nicklin 1981). While it is clear that outcomes vary based on individual physicians (Jha and Epstein, 2006), the characteristics of physicians that result in superior outcomes or more efficient resource use are not well documented. The main measures of physician human capital that have been examined are board certification and surgical volume. Our study is unique in that we will be able to examine the effect of medical school, residency training, board certification, and prior experience on patients' outcomes and resource utilization within hospitals. Investments in human capital should improve the knowledge and skills of physicians, which should make physicians better at processing and evaluating information. This, in turn, can help physicians improve the quality of care while using fewer resources. Despite the potential benefits of human capital investment on physician performance, the effects of medical school and residency training on health outcomes and efficiency have received little research attention.

Investments in human capital generally improve performance. Yet for physicians, it is difficult to determine which measures of human capital are most predictive of the quality of care they provide. Does the ranking of a physician's medical school or residency program make them more or less cost-efficient? Does it result in better or worse outcomes? While entrance into medical school may be indicative of native intelligence and prior schooling outcomes, selection into highly ranked residency programs may be a better predictor of health outcomes because it is based on performance in specialized medical programs and better information.

The impact of medical school and residency program rankings has not received much attention to date. Recent exceptions include Lichtenberg's (2009) study which finds that life expectancy increases are more rapid in states where the number of physicians trained in top medical schools is increasing. Weycker and Jensen (2000) find evidence that physicians from lower ranked medical schools or residencies are also more likely to be sued for medical malpractice. Although one study suggests that rankings impact costs but not outcomes, their dataset was extremely small and findings are not generalizable (Doyle, Ewer and Wagner 2008). Since our study is statewide, multiyear and multi-hospital, it should yield findings that can be applied to more settings.

Similar questions arise when considering the effects of experience. For example, although physicians with more experience may have gained more knowledge from years of practice, younger and less experienced physicians may be more familiar with the latest technologies in care. Numerous studies have found that physicians who have more experience with a particular surgery have lower patient mortality rates and fewer complications than physicians with less experience (Wen et al. 2006; Agency for Healthcare Research and Quality, 2004). In a study of eighty physicians treating potentially serious outpatient conditions, Leonard et al. (2007) find that the physician's length of training is an important determinant of their ability to properly diagnose the illness, and to communicate the diagnosis and treatment to the patient.

Hospitals, patients and managed care organizations often place great importance on board certification as well (Ya-Chen et al. 2007; Kinchen et al. 2004). Despite these preferences, the studies already mentioned provide only mixed evidence on the effects of board certification on healthcare quality and technology adoption.

Yet even these studies do not consider a broad range of human capital investment measures. None of the studies of board certification or experience incorporate information about the physician's medical school or residency ranking. Thus, many of these studies may suffer from omitted variable bias. They may also ignore significant interrelationships between various physician attributes. Is board certification used as a signaling mechanism or as a substitute for lower-ranked schooling? Does experience have a stronger influence on outcomes than residency ranking, or is there a certain threshold that must first be achieved? By including multiple measures of physician human capital and its quality, our study has the potential to closely examine the complementarities between these attributes and their impact on healthcare outcomes and costs.

A. Physicians and Outcomes

Patient mortality is a common measure of patient outcomes in empirical studies. Patient, hospital, and physician characteristics have all been found to have statistically significant relationships with patient mortality. Previous studies, specifically cited below, have typically examined the effect of two physician characteristics, surgical volume and board certification, on risk adjusted mortality rates. Our study is unique because we measure the impact of physician education, training, years of experience, board certification and prior procedural volume. We incorporate two measures of educational quality, the rank of the medical school attended and the rank of the residency program. The relationship between schooling and residency is unclear. We hypothesize that mortality rates are lower for patients treated by physicians from highly ranked medical schools or physicians from highly ranked residency programs.

Very few studies have analyzed the relationships between the quality of physicians' education and other post-graduate training and the mortality rate of their patients. Ferguson et al. (2002) review the literature on predictors of medical school success, and note that little has been done on post-medical school performance. An exception is Hartz, Kuhn and Pulido (1999), who measure physician performance using the mortality ratio, which is the surgeon's observed risk-adjusted mortality divided by the predicted mortality rate. They find no association between patient mortality and attendance at a prestigious medical school, residency, or fellowship program. They do not examine alternative patient level outcomes such as length of stay or costs incurred which may be affected by physician schooling and which are crucial in determining efficient resource use. A second exception is a study by Doyle, Ewer and Wagner (2008), who study the health outcomes of patients treated by physicians from one of two institutions, a higher-ranked institution and a lower-ranked institution. Although all patients are treated in the same hospital, they do not find any significant relationships between physician training and patient mortality when comparing physicians from the two educational programs.

We also hypothesize that mortality rates are lower for patients treated by board-certified physicians. Board certification is often used as a measure of physician human capital. While there is evidence in the literature that patient mortality differs by physician board certification status, the empirical results are mixed. Certification has been found to be associated with reductions in mortality following heart attacks (Kelly and Hellinger, 1987; Norcini et al. 2000). However, other studies find that physician certification can explain some differences in the use of appropriate medications, but has little difference on patient mortality rates (Chen et al. 2006; Hellinger 2008).

While board certification serves as an indicator of a physician's knowledge, physicians also accumulate human capital over time through experience. Three commonly used measures of physicians' accumulation of capital over time are procedure volume, years of experience, and physician age. Pearce et al. (1999) and Rogers et al. (2006) find positive effects of physician volume and board certification on mortality rates in Florida for some vascular surgery procedures and colorectal cancer surgery, respectively. For cardiac-related procedures, several studies have shown that higher volumes of coronary artery bypass graft surgeries by hospitals and physicians are associated with lower mortality rates (Wen et al. 2006; Agency for Healthcare Research and Quality 2004). We expect mortality rates to be lower for patients treated by physician with more years of experience or greater volumes of prior procedures.

B. Physicians and Resource Use

In addition to their impact on outcomes, physicians are also partly responsible for the hospital resources used in caring for inpatients. They decide what tests are needed, which procedures are performed and when the patient should be discharged; all of which have associated costs. Health insurers and hospital administrators also have some influence over resource use decisions, but their profits are more directly affected by decisions made by physicians. In their efforts to study cost-quality tradeoffs, policymakers may find new insights in the role that medical education plays in the efficiency and effectiveness of physician-directed care.

Past studies hint at a possible relationship between physician training and efficiency. One study finds such a link, but is impossible to generalize due to an extremely small sample size (Doyle, Ewer and Wagner 2008). Another study contends that decisions on care depend partly on the physicians' confidence and competence (Eisenberg 2002). Physicians who are more knowledgeable and/or clinically skilled may require fewer diagnostic tests in order to determine a proper diagnosis and treatment. To the extent that highly ranked medical schools and residency programs contribute to the physician's knowledge and skills, there is a possible link between physician training and resource use.

Doyle, Ewer and Wagner (2008) show that patients treated by physicians from a higher ranked school have shorter and less expensive stays than patients assigned to physicians from a lower ranked institution but do not find significant mortality effects. They conclude that the differences in treatment are consistent with the idea that physicians from lower ranked schools substitute time and diagnostic tests for the "faster judgments" of physicians from the top-ranked institution. Their study is limited to one hospital and physicians from two medical schools. In contrast, we will incorporate all Florida inpatients from 2000-2005 who are treated by physicians from over 100 medical schools and a wide range of residency programs, making results much more generalizable.

C. Technology Adoption

New medical technologies such as diagnostic tests, procedures, pharmaceuticals and equipment evolve rapidly in medicine. Physicians who adopt new technologies may be able to provide more effective and/or safer care to patients with a given condition. Alternatively, a new technology may be equally effective as existing procedures but cost significantly more. Physicians ultimately determine the marginal contribution of a new technology to overall healthcare experiences and patient outcomes through daily decisions on how intensely to use the new technology with patients.

We propose to study physicians' decision to adopt a new technology that was initially thought to improve quality of care when used on appropriate patients: drug-eluting stents approved by the Food & Drug Administration in 2003. We will examine whether technology adoption decisions vary by physician and, in particular, whether they are influenced by schooling and training. To the extent that the use of new technology can have major impacts on both costs and quality, our findings will be relevant both to policymakers and practitioners.
We expect technology adoption to vary significantly with the ranking of the physician's medical school, residency program, board certification, years of experience and procedural volume of care.

When new medical technologies are introduced, physicians' adoption decisions are influenced by their opinion on the existing technology, uncertainty regarding the quality and effectiveness of the new technology, and the psychic costs of adoption (Escarce 1996; Burke et al. 2007). Although physicians play a large role in determining the intensity of use of any type of care, few studies have examined the role of physicians in determining the speed with which a new medical technology is adopted. Of those studies that examine the adoption decision, even fewer have included a measure of physician human capital. Instead, most studies focused on physician specialty and practice setting (solo or group practice) as determinants of adoption. Rappaport, Forrest and Holtzman (2004) and Freiman (1985) examine the effect of time since graduation and board certification on technology adoption. Board certification was positively associated with earlier adoption (Escarce 1996; Freiman 1985). Escarce (1996) finds a U-shaped relationship between age and time of adoption. He also found that early adoption of the technology by some of the surgeons in a hospital significantly increased the probability of adoption by other surgeons in the same hospital.

Several studies have examined hospital decisions to adopt a major new technology such as a MRI machine (Baker 2001; Teplensky et al. 1995). Yet few studies have examined the determinants' of physician decisions to adopt a new clinical procedure, method of diagnosis, prescription drug or any other type of new medical technology. Escarce (1996) uses a hazard model to assess the impact of explanatory variables on the timing of adoption of laparoscopic cholecyctectomy by general surgeons. He estimates the quality of schooling using a coarse measure that simply dichotomizes graduates from U.S. medical schools from foreign schools, but finds no effect on the timing of adoption. In contrast to his study, we will measure quality of medical school using a national ranking of medical schools, and we will also incorporate the quality of residency and fellowship programs completed by cardiac physicians.

Our study will provide a significant step forward in the understanding of new technology adoption. We will look at a specific cardiac technology introduced during our study period. Drug-eluting stents were approved by the Food & Drug Administration in 2003. Typical of many medical technologies, the benefits required interpretation. These stents are more costly, but have been clinically shown to reduce readmissions (Stone et al. 2004; Moses et al. 2003). So while the immediate cost of the medical procedure might be higher, the total cost to the healthcare system should be lower.

III. Methodology

A. Physicians and Outcomes

We expect that physician characteristics will have statistically significant effects on patients' outcomes, even after controlling for patient and hospital characteristics. The clinical outcome measure is in-hospital mortality. To estimate a patient's outcome within a hospital, our level of observation is patient-physician-hospital specific. We use the Cox proportional hazard model to estimate the risk of mortality within the hospital:

$$h_t = h_{0,t} \exp(\alpha_1 P + \alpha_2 D + \alpha_3 H) \tag{1}$$

where P is a vector of patient characteristics such as age, H is a vector of hospital characteristics such as number of beds, and D is a vector of physician human capital measures such as medical school ranking. All of these variables are discussed in more detail below. This equation assesses the hazard rate h_t, which is the risk of mortality at time t conditional on survival to that time; and h_0 represents the baseline hazard, which is the individual heterogeneity. The Cox model is a common method for analyzing the effects of the right-hand side variables on the hazard rate because it requires no assumptions about the shape of the hazard function and the parameter estimates can be derived using a maximum partial likelihood estimator (Woolridge 2002; Greene 1997).

B. Technology Adoption

To explore whether physician characteristics are related to the adoption of a new medical technology, we examine the case of the drug-eluting stent.We will first measure the time between technology introduction and adoption. We then examine if the speed of adoption is related to a physician's medical school ranking, residency program ranking, board certification or experience. Specifically, we propose to estimate the equation below, which represents the hazard of discrete stent adoption by physicians. We define adoption as an indicator equal to one if the physician has used drug-eluting stents three times. In contrast to equations (1) & (2), which are patient-physician-hospital specific, the level of observation for the adoption of new technology is physician-specific. Following the methods of Burke et al. (2007), we assume the adoption hazard follows a complementary log-log hazard model. We chose this model because our data are collected quarterly and we do not have exact dates on which procedures were completed, so we observe whether a physician began using drug-eluting stents in quarterly intervals. The model is

$$\log(-\log(1 - pr_{dt})) = c_t + \gamma_0 D_{dt} + \gamma_1 X_{dt} + \gamma_2 A_d + \mu_h \quad (3)$$

The probability of adoption at a given time depends on the current calendar date (c_t), the human capital characteristics D of physician d at time *t*, averages of the characteristics of the physician's patients, X, and A is a vector of two variables that measure the physician's access to informal information on drug stents: a binary indicator for whether the physician has a faculty appointment; and a binary indicator for whether another physician in the hospital has adopted drug stents (used them at least three times). Many physicians practice at more than one hospital, making the inclusion of hospital characteristics redundant. Instead, we include fixed properties of the hospital(s) where the physician practices (one indicator, μ_h, is included for each hospital in which the doctor practices).

We assume that only physicians who were previously practicing angioplasty would consider adoption of the stent. That is, non-invasive cardiologists who mainly perform diagnostic tests and cardio-thoracic surgeons, who perform open heart surgeries, would not be expected to perform percutaneous coronary intervention. Although our data covers the time period 2000 – 2005, since the first drug-eluting stent was not introduced until April of 2003, our analysis of adoption will only use data from the second quarter of 2003 to the last quarter of 2005. Based on these conditions, this facet of our study uses a subset of all hospital discharges. It will include only patients who are treated after April 2003 by a physician who completed at least one angioplasty procedure in the prior year.

We hypothesize that among interventional cardiologists, physicians who are from higher ranked schools, completed a residency at a top heart hospital, are board certified, who have more years of experience or have performed more angioplasty procedures in the past will adopt the drug-eluting stents earlier. Since we consider education and experience to be forms of investment in human capital following Becker's classic model (1975), we expect higher human capital to be associated with greater ability to process, evaluate, and interpret the emerging information on drug-eluting stents.

C. Hospital Fixed Effects and Hospital Characteristics

One of the specific goals of this project is to determine whether physician characteristics impact the relationships between hospital characteristics and inpatient mortality rates, charges, and length of stay. As shown in the previous section, when estimating equations (1) and (2) we will include the hospital characteristics shown in Table 2. Characteristics such as ownership, teaching status and bed size are commonly used in other studies of healthcare costs and outcomes. A hospital's efficiency, as measured by full-time equivalent nurses per bed, might influence outcomes independent of physician characteristics. Even a highly skilled physician could get mediocre results if a hospital is under-staffed. A Herfindahl index measures the size of a hospital, based on the hospital's admissions, in relation to the hospital's market, thus indicating the competitive pressures facing the hospital. And the presence of a cardiac catheterization lab demonstrates specific capability.

Including hospital characteristics in the model is important because many previous studies have found that hospital characteristics have a key role in determining patients' outcomes and treatment. Results from our study will allow us to compare the estimated impact of hospital characteristics on in-hospital mortality and intensity of care when physician characteristics are also included in the model. However, we may not be able to control for all the hospital characteristics that influence patient outcomes. If there is an unobservable hospital characteristic that is related to the outcome of interest and is also correlated with an explanatory variable, then our estimated coefficients will be biased. For example, either the availability of technology at the hospital or the hospital's administrative policies could influence both the length of stay at the hospital (a dependent variable) and the number of prior procedures a physician has completed (an explanatory variable).

Our strategy for addressing this challenge is to also estimate equations (1) and (2) without the hospital characteristics and instead including hospital fixed effects. By including hospital fixed effects we control for observable and unobservable hospital characteristics that differ across hospitals. This allows us to examine how physician characteristics are related to a patient's outcome and treatment within a hospital, while holding the hospital characteristics constant across all patients.

D. Inclusion of Physician Characteristics

This study employs five alternative measures of a physicians' development of human capital: medical school ranking, residency program ranking, board certification, experience, and volume of procedures. If all five characteristics are included in a single estimated equation, we must consider the possibility of multicollinearity between the measures of physician human capital. For example, physicians who graduate from top-ranked medical schools may also be more likely to be board certified. And physicians with more years of experience may be more likely to have higher volumes of previous procedures. If multi-collinearity is present, it will not reduce the predictive power of the model as a whole. However, the reliability of the estimated impact of one individual physician characteristic on the outcome of interest will be reduced.

We will address this challenge in two ways. One strategy is to test for multicollinearity when estimating equations that include all five measures of physician capital. A simple test for multicollinearity is to examine the variance inflation factor of the explanatory variables included in a model. Variance inflation factor values which are greater than 10 indicate that an explanatory variable could be considered as a linear combination of other independent variables, and the standard errors for the coefficients are inflated (Chen et al. 2003). Our second strategy for addressing the possible challenge of multicollinearity is to estimate each equation with only one physician characteristic at a time. This will allow us to compare the impacts of the physician characteristics on the outcomes of interest across equations, and when all physician characteristics are included in one estimated model. If multicollinearity is found when all physician characteristics are included in an estimated equation, our conclusion will rely more heavily on the estimates found when the equations are estimated separately for each physician characteristic.

E. Controlling for Patients Health

One challenge to analyzing the impact of physician characteristics on patient outcomes is to adjust for patients' health status. If there are unobserved patient health characteristics that affect both the attributes of the physician treating the patient and the patient's outcome, estimated results could be biased. A common problem is that patients who are in worse health and/or who have more complications may need to be treated by physicians from higher ranked programs or by more experienced physicians. These sicker patients, however, are more likely to need more intensive or expensive treatments, to have longer hospital stays, and to have higher mortality rates. We include three controls for patients' health. First, we control for 11 secondary diagnoses which would indicate the health status of the patient at the time of admission, following Baker et al. (2001): diabetes, hypertension, cancer, dementia, stroke, vascular disease, an old myocardial infarction, other heart disease, pulmonary disease, respiratory disease, and obesity.

Second, we construct a measure of survival risk, the ICD-9 Injury Severity Score (ICISS). For each of the patient's ICD-9 diagnoses (one primary and up to nine secondary), survival risk ratios (SRRs) are derived by dividing the number of survivors in each ICD-9 code by the total number of patients with the same ICD-9 code. ICISS is calculated as the simple product of the SRRs for each of the patient's diagnoses. The ICISS has been shown to outperform other standard measures of patient severity in recent empirical work by Osler et al. (1996); Rutledge et al. (1998); and Huynh, Guy, and Rutledge (1998). For each quarter of our data, we construct the ICISS using the entire population of discharges from all hospitals.

Our third method for controlling for patients' health is based on the patients' primary cardiac diagnosis code. We categorize diagnosis-related groups (DRGs) according to average DRG weights, which indicate the relative severity of the patient's illness and are directly proportional to DRG payments. We create four diagnoses severity indicators: 'very severe', 'severe', 'somewhat severe' and 'mild,' where the latter is the omitted category.

IV. Data Sources

This study is based on Florida hospital discharges for cardiac cases from 2000 to 2005. To measure the influence of physician experience and schooling, those patient records are matched to data on physician and hospital characteristics. Patient and hospital data come from the Florida Agency for Health Care Administration.

Patient data from the Florida Agency for Health Care Administration captures a great deal of information for every inpatient stay. The broad range of variables is summarized in Table 1, and includes patient demographic information, payer type and case complexity. Identifiers for both attending and operating physicians are also included on discharge records, and are used to link to physician characteristics. We will use data from 2000–2005 in the proposed study, but the sample statistics in Table 1 are based on patients treated in 2004. The "Cardiac Population" is all inpatients with a Major Diagnostic Category of 'Diseases and Disorders of the Circulatory System', and the "Cardiac Sample" columns show statistics for patients who are treated by a physician for whom schooling or residency data is available. The "Stent Adoption" columns show statistics for the stent adoption sub-study. In Table 1, this sub-sample includes only patients in 2004 who are treated by physicians who had performed an angioplasty procedure in 2003. Since drug-eluting stents were introduced in the U.S. in 2003, this sub-sample is used to measure technology adoption speed of physicians.

This study examines the cost and outcome implications of a physician's training, certification, experience and volume. These key variables are summarized in Table 2 by patients' mortality, length of stay, and total charges.

Quantification of physician training variables begins with data on physician schooling and residency provided by the Medical Quality Assurance (MQA) division of the Florida Department of Health. Characteristics of the operating physician who treats the patient are used, or if the patient does not have an operating physician, the characteristics of the attending physician.

Physician information is then linked with the U.S. News & World Report annual rankings of U.S. medical schools (USNWR 2006a) and cardiac care hospitals (USNWR 2006b). The medical school ranking is based on the schools' selectivity in admitting patients. According to the USNWR, schools are ranked "from most to least selective based on a formula that combines average MCAT scores and undergraduate GPA for the entering class as well as the school's acceptance rates" (USNWR, 2006a). Once the ranking link is made, we determine whether the physician graduated from one of the top 30 medical schools. Another variable indicates whether the physician completed a residency at one of the top 50 cardiac care hospitals, and is similar to the definition of "star" physicians in Burke, Fournier, and Prasad (2007).

Board certification information also comes from MQA and indicates whether the physician is board certified in an area related to cardiac care. The length of experience is computed using the physician's first year in practice (from MQA).

Another measure of physician experience is their case volume. We use our hospital inpatient data to construct a measure of the number of angioplasty procedures a physician performed for three years prior to the date of service. For example, for surgeries performed in 2004, our measure of procedural volume for each physician is the number of inpatient angioplasties that physician performed from 2001 – 2003. The impact of prior angioplasty procedures will be estimated using a sub-sample of the data. As stated previously, when estimating the impact of volume of angioplasty procedures on patients' outcomes and intensity of resource use, we will only include a patient's observation if the physician treating the patient completed at least one angioplasty procedure in the prior year.

V. Conclusion

Physicians play a primary role in determining a patient's treatment and in directing healthcare expenditures. However, the characteristics that make for an efficient and effective physician are not well understood. Complicating matters further, a physician may make efficient use of his or her own time at the expense of ordering inefficient tests. Using 5 years of data on cardiac inpatients in Florida hospitals and their attending and operating physicians, we construct a unique dataset that allows us to match patient, physician, hospital and geographic characteristics for each episode requiring hospital admission. For each physician treating a patient, we have information on medical school attended, residency program, date of graduation and board certification.

Our key innovation is the introduction of the quality of physician training as a new determinant in the study of healthcare costs and outcomes. Findings from this study can have broad ranging applications. If medical school or residency rankings are found to be significant determinants of resource use, that is an important first step to help programs turn out more efficient physicians. And if those same rankings have impact on outcomes of only certain types of patients, policymakers can examine whether training programs have certain 'blind spots'. Continuing medical education courses could be designed to equalize the efficiency and effectiveness of physicians from training backgrounds of various rankings. In addition, results from this study can inform physician credentialing decisions or aid patients in making more informed physician choices. Finally, our results may provide educators information on the post-graduation performance of their students, which can help in the design of new educational strategies.

Tables

Table 1. Means and Standard deviations of Patients' Characteristics, Year = 2004

Patient Characteristics:	**Cardiac Population Means (Std. Dev.)**		**Cardiac Sample Means (Std. Dev.)**		**Stent Adoption Means (Std. Dev.)**	
In-hospital Mortality	0.023	(0.148)	0.022	(0.147)	0.018	(0.134)
Length of Stay	4.149	(4.794)	4.126	(4.764)	4.512	(5.437)
Total Charges	33,609	(42,469)	33,301	(42,085)	49,186	(51,329)
Patient's Age	67.143	(16.079)	66.916	(16.069)	66.210	(14.435)
Female (%)	0.474	(0.499)	0.475	(0.499)	0.409	(0.492)
Black (%)	0.130	(0.337)	0.133	(0.339)	0.107	(0.309)
Hispanic (%)	0.120	(0.325)	0.120	(0.325)	0.109	(0.312)
Uninsured (%)	0.041	(0.199)	0.043	(0.202)	0.038	(0.191)
Medicare (%)	0.630	(0.483)	0.624	(0.484)	0.610	(0.488)
Medicaid (%)	0.057	(0.232)	0.059	(0.235)	0.049	(0.216)
Private Insurance (%)	0.230	(0.421)	0.232	(0.422)	0.258	(0.437)
Patient Survival Risk (ICISS)	0.792	(0.160)	0.793	(0.160)	0.795	(0.159)
Patient received PTCA	0.131	(0.337)	0.127	(0.333)	0.272	(0.445)
Patient received CABG	0.046	(0.209)	0.046	(0.210)	0.099	(0.299)
Patient had AMI	0.039	(0.194)	0.039	(0.193)	0.082	(0.274)
DRG Severity (%):						
Very Severe	0.410	(0.492)	0.419	(0.493)	0.185	(0.388)
Severe	0.275	(0.447)	0.275	(0.446)	0.247	(0.431)
Somewhat Severe	0.076	(0.265)	0.074	(0.262)	0.095	(0.293)
Mild	0.239	(0.427)	0.232	(0.422)	0.474	(0.499)
Secondary Diagnoses (%):						
Diabetes	0.164	(0.370)	0.165	(0.371)	0.163	(0.369)
Hypertension	0.364	(0.481)	0.365	(0.481)	0.381	(0.486)
Stroke	0.022	(0.145)	0.021	(0.145)	0.018	(0.133)
Vascular Disease	0.028	(0.165)	0.027	(0.163)	0.034	(0.182)
Pulmonary Disease	0.184	(0.388)	0.184	(0.387)	0.161	(0.368)
Respiratory Disease	0.047	(0.212)	0.047	(0.212)	0.052	(0.221)
Prior Myocardial Infarction	0.038	(0.192)	0.038	(0.191)	0.047	(0.212)
Obese	0.166	(0.372)	0.166	(0.372)	0.162	(0.368)
Other Heart Disease	0.295	(0.456)	0.293	(0.455)	0.303	(0.459)
	(n = 488,337)		*(n = 382,504)*		*(n = 172,253)*	

Table 2. Patients' Outcomes and Intensity of Care by Physician Characteristics, Year = 2004

Physician Characteristic	Number of Patients	In-Hospital Mortality (%)	Mean Patient Length of Stay	Mean Patient Total Charges ($)	Drug Stent Adoption Rate (%)
Training					
Top 30 Medical School	42,653	0.023	4.232	35,004	35.2
Not Top 30 Medical School	329,097	0.022	4.124	33,175	35.1
Top 50 Residency	73,011	0.020	3.984	32,473	38.3
Not Top 50 Residency	248,826	0.023	4.117	33,224	35.6
Certification					
Board Certified	263,403	0.022	4.098	33,373	36.6
Not Board Certified	119,101	0.023	4.206	33,337	32.6
Years of Experience:					
0 – 10 years	111,535	0.021	4.022	32,578	35.1
11 – 15 years	83,073	0.022	4.247	35,471	41.2
16 – 22 years	94,381	0.023	4.149	33,671	35.6
More than 22 years	93,515	0.024	4.153	31,866	29.9
Volume of Angioplasty Procedures, 2003:					
1 – 2	25,870	0.027	5.057	30,040	9.8
3 – 4	10,548	0.026	6.974	44,318	19.6
5 – 37	39,395	0.020	6.231	72,925	34.0
More than 37	77,382	0.011	3.135	42,548	97.0

Table 3. Means and Standard deviations of Hospitals' Characteristics, Year = 2004

Hospital Characteristics:	**Cardiac Population[1] Means (Std. Dev.)**		**Cardiac Sample Means (Std. Dev.)**		**Stent Adoption Means (Std. Dev.)**	
	(n = 488,337)		*(n = 382,504)*		*(n = 172,253)*	
Not for Profit (%)	0.501	(0.500)	0.508	(0.500)	0.554	(0.497)
Government (%)	0.108	(0.310)	0.104	(0.305)	0.107	(0.309)
For-profit (%)	0.390	(0.488)	0.387	(0.487)	0.339	(0.473)
Teaching (%)	0.085	(0.280)	0.086	(0.281)	0.123	(0.328)
Number of Beds	458	(376)	457	(377)	560	(423)
Nurses per Bed	1.151	(1.631)	1.143	(1.635)	1.077	(1.531)
Catheterization Lab (%)	0.882	(0.323)	0.884	(0.321)	0.962	(0.192)
County Herfindahl	0.496	(0.286)	0.498	(0.286)	0.487	(0.279)
Risk-Adjusted Average Heart Failure Charge ('000s)	23,054	(7,205)	23,050	(7,189)	22,777	(6,607)