Vertical Integration and Treatment Choices: Evidence from Cardiologists*

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Abstract

I study the effects of integration between referring physicians and specialists in cardiology. To address concerns of endogeneity of integration, I exploit a change in Medicare payment rates which increased the financial benefit to vertically integrating for cardiologists. Instrumental variables estimates show that cardiologists who work in the same practice as cardiac surgeons are 7.7% more likely to refer patients for surgery rather than more conservative options. Patients diagnosed by integrated cardiologists in turn have worse mortality and readmission outcomes, with 18.7% higher mortality risk and 13.4% higher risk of readmission for AMI within 180 days. This is in spite of the fact that patients diagnosed by integrated cardiologists have 7.8% higher medical spending in the 180 days following diagnosis. I provide evidence that these effects are not driven by inherent risks of invasive surgery or selection on patient observables, but worse outcomes for patients receiving the most conservative treatment option.

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1 Introduction

Over the last two decades, healthcare markets in the United States have become increasingly consolidated. This integration has been both horizontal, such as the hospital mergers, and vertical, such as the rapid acquisition of physician practices by hospitals and multispecialty practices. While there is a long literature studying the effects of horizontal market concentration and mergers in health care, particularly in the hospital industry, other forms of integration are not as well understood.

Of particular interest to both researchers and policymakers is the integration of physicians with other types of providers, due to the unique role physicians play in health care. One of the primary functions of many physicians, especially those serving in specialty fields, is to provide care to patients. However, physicians also serve as the primary source of information for patients about the types of care they need and which providers to seek care from, providing referrals to appropriate providers. For many patients, a physician's recommendation is second only to inclusion in a patient's insurance network when choosing a provider. (Arrow, 1963; Ziemba et al., 2017)

Partly because physicians serve multiple functions within the health care system, effects of such forms of integration are ambiguous. Proponents argue that integration of different types of providers will enable physicians to coordinate care more effectively, improving patient outcomes, while reducing costs.[1] This principle underpins several attempts at payment reform, such as Medicare's Accountable Care Organizations and the Alternative Quality Contract in Massachusetts. In contrast, opponents argue that integration will lead to higher prices, by enhancing providers' market power and lead to patients being steered to in-system providers and treatments.[2]

[1] Cutler (2010)
[2] King and Brown (2016)

In the United States, financial integration is one of the only tools for health care providers to incentivize referring physicians, due to regulations known as Stark Law. These regulations prohibit physicians from referring to health care entities in which they have a financial interest. However, Stark Law provides an exception for ”bona fide employment arrangements” (42 CFR § 411.357(c)). In other words, physicians are not barred from referring to an entity if they are directly employed by it. While they are still not able to provide direct financial incentives, in the form of payments for referring patients to in-system providers, firms can impose indirect and informal incentives. For instance, physicians may be paid partly in revenue sharing or profit sharing agreements, which provides an indirect incentive to refer patients in-house. Alternatively, physicians may come under informal social pressure for not referring enough patients in-house. At their most extreme, health care systems may even attempt to prohibit referrals to outside providers. For instance, Steward Health was accused of cancelling a patient's scheduled treatment at an out-of-system hospital for a treatment Steward did not provide in a lawsuit filed in 2018. (Kowalczyk, 2018)

This paper empirically examines the role of integration between cardiologists and cardiac surgeons in the choice of treatment for cardiac patients. Using Medicare data on the diagnosis and treatment of cardiac patients, I find that patients are 7.7% more likely to receive surgical interventions following diagnosis by an integrated cardiologist. Consistent with prior literature, this shift to surgical interventions increases healthcare utilization. However, my results also show that patients have 18.7% higher mortality risk and 13.4% higher readmission risk. Lastly, I show that these are not driven by inherent risks to undergoing surgery. Instead, my results suggest medically managed patients receive less effective care at integrated cardiologists.

One of the primary difficulties in studying integration of any sort is the lack of plausibly exogenous variation. To ameliorate these concerns, I use an instrumental variables strategy to show my results are robust to the most likely sources of endogeneity. To do so, I exploit a change in Medicare payment rates in 2010, which changed the financial benefits to billing in hospital outpatient departments for many physicians. This variation is driven by an update to the underlying cost estimates used by CMS to set physician payment rates in 2010, an update also studied in Dranove and Ody (2019).

Using the predicted probability of vertical integration from the logit first-stage as an instrument for integration, I first investigate how integration affects choice of treatment. Conditional on patient risk characteristics, I find the likelihood of surgical intervention increases by approximately 7.7% due to vertical integration. While likelihood of surgery increases, patients are steered away from medical management, the most conservative treatment option, rather than reallocated between interventional treatment options.

After establishing that patients receive more surgery overall, I show that inpatient utilization is $\$1,879$ higher for patients diagnosed by vertically integrated cardiologists. Decomposing this spending into separate categories, I find that this increase is largely driven by an increase in inpatient spending due to higher hospital readmission rates.

Next, I turn my attention to how patient hospitalization and mortality outcomes differ, finding worse outcomes for both, with patients approximately $0.83pp$ more likely to die and $0.51pp$ more likely to be readmitted to the hospital for a heart attack within 180 days of diagnosis. There are a number of possible explanations for this finding. First, since interventional procedures carry inherent risks, this may be simply a side effect of increased interventions. However, I find that outcomes worsen conditional on the type of treatment, suggesting this is not the primary driver. Another possibility is that the patient mix diagnosed by vertically integrated cardiologists is different than that seen by non-integrated cardiologists, however they appear similar along observable dimensions.

Despite concern by policy makers and industry insiders about the effects of vertical integration on patient choice, academic literature has largely focused on its price and outcome effects. For instance, it is well documented that vertical mergers are associated with higher spending and prices (Capps et al., 2017; Baker et al., 2014). Despite increased spending, there is limited evidence of improvement in patient outcomes due to integration (Koch et al., 2018).

While these issues are undoubtedly important, relatively little work has been done studying the referral effects of vertical acquisitions. Two recent works in this small literature are Baker et al. (2016), who find that ownership of a patient's primary physician by a hospital increases the likelihoodof choosing that hospital and reduces the cost-sensitivity of the choice function to zero. The other recent work in this literature is Brot-Goldberg and de Vaan (2018), who uses Massachusetts data to study how integration impacts the choice of orthopedist and patient utilization after diagnosis. They find that patients referred in practice have lower utilization, but that steering effects are extremely strong, accounting for approximately half of all in-practice referrals. In contrast, cost efficiencies have almost no impact on specialist choice, due to cost insensitivity of primary care physicians and consumers when choosing providers. In contrast to this work, I focus on the initial choice of treatment, rather than the choice of provider. While they have a section on the margin whether to receive surgery, the primary focus of the work is on selection of surgeon conditional on getting surgery.

The most closely related work to this one is Afendulis and Kessler (2007), who study how treatment decisions of cardiologists differ when they perform interventional services in addition to diagnostic services. Their results show that diagnosis by an interventional cardiologist increases a patient's utilization post-diagnosis, but also improves outcomes, suggesting they are better able to allocate sicker patients to appropriate care. My work differs from theirs in two fundamental ways. First, their study uses geographic variation in a two-stage procedure[3] to identify the effect of integration, while I use variation in integration generated by changes in Medicare payment rates to identify the effect of integration. At a more fundamental level, the form of integration they study is arguably less relevant to policymakers because it is not driven acquisitions and other areas of health care research than the integration I study.

This paper also contributes to the sizable literature showing financial incentives to healthcare providers has large impacts on patient steering. Much of this literature has focused on alternative payment contracts, such as Ho and Pakes (2014), who study capitation contracts in California, showing that such contracts increase cost sensitivity without reducing outcomes. Similarly, Song et al. (2011) find that the Alternative Quality Contract in Massachusetts reduced beneficiary spending, primarily by shifting specialist referrals to lower-cost providers.

Lastly, this paper builds on a large literature documenting provider responses to Medicare payment rules. For instance, Capps et al. (2017) find that physicians who are acquired by hospitals shift their billing to facility based settings in order to take advantage of higher facility-based payment rates. In closely related work, Dranove and Ody (2019) find that a 2010 update to data used to Medicare physician payments led to an increase in hospital employment in physicians, by increasing the gap between facility and office based payment amounts. This is the same variation I exploit as exogenous variation in vertical integration for cardiologists. Studying long-term care hospitals, Eliason et al. (2018) and Einav et al. (2017) both study the impact of a discontinuity in provider reimbursements, finding that hospitals disproportionately discharge patients immediately after receiving a lump sum payment for care.

The remainder of this paper proceeds as follows: Section 2 provides a description of

[3] Their procedure is similar to two-stage least squares, but differs in that the second stage of their choice model is a multinomial logit, rather than a linear model.

the cardiac catheterization market. Section 3 describes the construction of the primary dataset from Medicare claims. Section 4 describes the empirical strategy, including a description of the Medicare fee setting process. Section 5 presents estimates of the effect of integration on treatment choices and patient outcomes. Lastly, Section 6 explores possible mechanisms driving these results and Section 7 concludes.

2 Empirical Setting

2.1 Cardiac Catheterizations

Coronary angiography, or diagnostic cardiac catheterization, is a procedure developed in the 1950's in which a doctor inserts a catheter into a patient's groin and uses injectable dye to diagnose blockages in a patient's heart. Once the catheter is inserted, the doctor uses dye and an imaging machine to locate blockages in the patient's arteries.

After the doctor has located any potential blockages, they recommend a further course of treatment. After diagnosis, there are three treatment options available to patients. The most inexpensive and least invasive option is medical management of symptoms. This course of treatment consists primarily of using prescription drugs to break up any blockages and reduce the potential negative effects of future blockages, should they reoccur. This is the treatment choice for apprximately two-thirds of patients, especially those diagnosed in an elective setting.

The most common alternative to medical treatment for arterial blockages is an interventional catherization,[4] called percutaneous coronary intervention (PCI). This procedure involves inserting a catheter into a patients arteries, in a similar fashion to diagnostic

[4]For the purposes of this paper, I will use "cardiac catheterizations" or "catheterizations" to refer to diagnostic catheterizations, rather than interventional catheterizations.

catheterizations. Afterwards, the physician removes the blockage by inserting a small balloon and expanding it and potentially inserting a stent. Frequently, these are performed in the same procedure and by the same physician as the diagnostic catheterization. Cardiologists who perform both PCI's and diagnostic catheterizations are called interventional cardiologists, though in recent years, the vast majority of cardiologists are interventional.

Finally, patients may be referred to a cardiac surgeon for cardiac arterial bypass graft (CABG) surgery. CABG is a surgical procedure in which arteries from a different location of the body, such as the leg, are grafted to bypass blockages in the arteries surrounding the heart. For many years, this was the treatment of choice for patients requiring cardiac intervention. Since the mid-1990's, however, U.S. CABG volumes have been on a consistent decline. Importantly, the vast majority of patients do not regularly interact with cardiac surgeons. Instead, they are advised on their options by their cardiologist, who would recommend one of the available treatment options.

Guidelines for the treatment of heart attack and angina are regularly published by the American College of Cardiology and American Heart Association. (Antman et al., 2008; Anderson et al., 2007) Medical management is preferred for low-risk female patients and patients who have high risk of adverse clinical events, for example. Angioplasty is the most common form of intervention chosen, though several factors can make bypass more appropriate, such as multivessel coronary artery disease or diabetes mellitus.

Despite the detailed nature of these guidelines, there is no set algorithm for selecting a treatment. This lack of a set algorithm leaves significant latitude for physician judgement in the choice of treatment. This is made clear in the guidelines: "Although general guidelines can be offered, individual judgment is required." (Anderson et al., 2007) It is unlikely physicians frequently recommend wholly unsuitable treatments. Physicians treating patients on the margin, however, may be swayed by the underlying financial incentives.

2.2 Vertical Integration in Cardiology

This setting also provides the distinct advantage that vertical integration has increased substantially during the study period. In my data, the portion of procedures performed by cardiologists who work in the same practice as surgeons increased from 15.0% in Q1 2008 to 27.3% in Q4 2012. This is in line with other studies, such as Nikpay et al. (2018) which found that hospital employment of cardiologists nearly tripled from 2007-2017.

All physician specialties have increased their level of integration, similar to all of healthcare, but cardiology experienced a uniquely high rate of change, largely due to changes in Medicare fee structures. In 2010, the Center for Medicare and Medicaid Services (CMS) introduced a change in physician payments which substantially increased the benefit to billing in a hospital outpatient department relative to a physician office. There is substantial evidence suggesting this led to cardiologists selling their practices to hospitals to take advantage of higher hospital payment rates.(Song et al., 2015; Dranove and Ody, 2019; American College of Cardiology, 2010)

3 Data

The primary data for this analysis are the Medicare Carrier 20% file from 2008-2012. These data consist of all physician services claims for a 20% sample of enrolled Medicare Part B beneficiaries. Each claim contains identifiers for the physician and practice billing for the procedure, along with detailed diagnosis and procedure information. These data are well suited to this study for a number of reasons. First, diagnostic catheterizations are an extremely common procedure in the Medicare population, with roughly half of all procedures being performed on Medicare patients. This not only provides a large sample size, but allows me to accurately determine the set of cardiologists and cardiac surgeons performing at a given point in time. Second, detailed diagnostic information allow me to include detailed controls for differences in patients' health history. I supplement these data with medical claims from non-physician sources of care (e.g. inpatient claims) in order to construct outcome and risk measures for each patient.

3.1 Primary Variable Construction

Treatments Using Common Procedural Terminology (CPT) codes, I identify all diagnostic catheterization, PCI, and CABG claims in the Carrier claims file.[5] Each catheterization is assigned to the treatment they receive in the month following diagnosis. If a diagnosis is followed by both PCI and CABG claims, they are assigned to CABG.[6] I exclude any claims which are denied.

Physician Employment Included on each claim in the Carrier file is the Tax Identification Number (TIN) of the practice billing for the claim, along with the National Provider Identifier (NPI) for the performing physician. Following other work on physician acquisitions, I use the TIN as the firm definition for this study (e.g. Capps et al., 2017; Walden, 2016). I leverage these two identifiers to construct a panel of physician employment by assigning each physician to the practice in which they bill the most claims in each quarter.[7]

I define any practice which employs both cardiologists and cardiac surgeons in the current quarter as vertically integrated. In order to be classified as a cardiac surgeon, a physician must report a specialty of general, cardiac, or thoracic surgery and perform at least 5 cardiac bypass procedures during the entirety of my sample.[8] This differs slightly from the definition used in Dranove and Ody (2019), which defines vertical integration as

[5] See Appendix D for a list of CPT codes used to identify each procedure.
[6] This is consistent with the assignment used in Culler et al. (2015).
[7] This is not a problematic assumption, as $>$ 90% of physician-quarters bill under a single TIN.
[8] Specifically, I require they report a Healthcare Provider Taxonomy Code (HPTC) of 03, 33, or 78.

ownership of a practice by a hospital. Since surgical specialists are among the most likely specialties to work for hospitals, these two measures will be correlated, but not identical.[9]

This measure of integration is subject to notable measurement error, because two practices which are owned by the same firm do not necessarily bill under the same Tax ID. One common example of this is for hospitals to have different Tax ID's for the practices of each of its specialties. It is difficult to directly determine by how much this measure of integration understates the true value. However, Baker et al. (2018) compares measures of HHI using TIN's in Medicare claims with those calculated using hospital and system ownership information from a commercial dataset from SK&A, yielding very similar values, especially in cardiology. While not the exact measure of integration I am using, this suggests measurement error is likely small. Nevertheless, using an IV addresses such concerns.

Patient And Hospital Characteristics If integrated cardiologists see patients who are systematically different than those seen by non-integrated cardiologists, it would be natural for them to recommend different treatment options and have different outcomes. To account for this, I follow the medical literature to adjust for patient risk.(Elixhauser et al., 1998) Specifically, I calculate the Elixhauser Index for each diagnosis, along with indicators for the existence of Elixhauser comorbidities using the International Classification of Diseases (ICD-9) codes from all claims for the patient in the 12 months leading up to diagnosis.[10] These variables, along with patient sex, risk, and race are used to risk-adjust for patient characteristics.

Additionally, I control for regional sociodemographic characteristics using data from the Area Health Resources File (AHRF). Specifically, I control for the percent of adults with at least a bachelor's degree, median age, and median income for the county in which

[9] Nikpay et al. (2018)

[10] This is consistent with prior studies, such as Afendulis and Kessler (2007) and Brot-Goldberg and de Vaan (2018).

a patient resides. Lastly, using data from the Provider of Services file provided by CMS, I include the bed count, for-profit status and teaching status of the hospital at which the cath occurs.

Patient Outcomes I focus on three primary patient outcome measures: hospital readmission, healthcare utilization, and mortality. I measure utilization as total payments for the patient from the date of diagnosis and until the end of the observation window. Because this includes the diagnosis and any treatments, this will include any spending differences attributable to treatment choices. Hospital readmissions are identified ignoring the month following diagnosis, as these admissions are potentially part of the original course of treatment.

3.2 Sample Restrictions

After constructing the overall panel of diagnoses and treatments, I restrict the sample in a number of ways. I first drop any diagnoses which are performed by cardiac surgeons, to remove potential issues arising from integration of the same physician. Second, I drop any observations where the billing provider is not a cardiologist. This excludes claims where a group practice is listed as the billing provider or where a non-cardiologist physician performs the procedure, such as a radiologist.[11] Lastly, I drop any claims with a diagnosis code indicating ST-elevated myocardial infarction[12], as there is clear guidance for many of these patients to receive interventional catheterization upon reaching the hospital, leaving less scope for physician decision making.[13] Lastly, to ensure accurate construction of risk and outcome measures, I restrict attention to those patients who were continuously enrolled in Medicare Parts A & B for the 12 months prior to diagnosis in order to accurately

[11] Specifically, providers must report an HPTC code of 06 or C3 and an entity type 01.

[12] ICD codes 410.x, other than 410.7x.

[13] ACC/AHA Guidelines state: "Primary PCI should be performed in patients with STEMI and ischemic symptoms of less than 12 hours' duration." Antman et al. (2008)

construct measures of patient severity. Lastly, when considering 180-day outcomes, I restrict attention to those who are continuously enrolled in Medicare for 180 days following diagnosis or until their death.

In Table 1, I show baseline summary statistics for this sample. Imposing these sample restrictions generates a sample of $675,789$ catheterizations performed by $12,308$ cardiologists. Of these, I observe $2,155$ perform catheterizations before and after integration with a surgeon. From this table, it is notable that mortality and readmission are both rare events, with 4.45% of patients dying and 3.77% of patients being readmitted within 180 days. Additionally, spending is very high for these patients, at $\$24,063$ on average in the 180 days following diagnosis.

4 Empirical Strategy

Identifying the effect of integration on treatment choices is difficult, as there is substantial heterogeneity in both patients and physicians. While I posess very detailed data on patient characteristics, this does not control for all potential sources of heterogeneity. There are two very likely sources of endogeneity. First, patients with a high propensity for surgery may seek out integrated physicians, biasing the estimate of β upwards. Second, physicians who are more likely to refer patients for surgery may be more likely to integrate with surgeons. While this is by no means an exhaustive list of potential sources of endogeneity, these examples illustrate the cause for concern. Such concerns are exceedingly common in studies of integration effects, both in healthcare and industrial organization more broadly, with a variety of methods utilized to address them.[14]

[14]For such examples in healthcare: Afendulis and Kessler (2007); Dunn and Shapiro (2014); Kessler and McClellan (2000); Gaynor (2004); Dafny (2009); Capps (2005); Hayford (2012); Cutler et al. (2017). For examples in non-healthcare settings, see: Prince and Simon (2017); Fan (2013); Hortaçsu and Syverson (2007); Januszewski Forbes and Lederman (2009)

To address these concerns, I instrument for integration with a surgeon using a physician's exposure to a 2010 update to the Medicare Physician Fee Schedule.

4.1 Medicare Physician Fee Schedule

The Center for Medicare and Medicaid Services (CMS) administratively sets prices for physician services each year according to their estimate of the relative cost of providing each procedure.[15][16] To do so, CMS assigns each procedure a number of Relative Value Units (RVUs) based on four factors: the physician work required to perform the procedure, estimates of the practice expenses associated with a procedure, the malpractice risk associated with the procedure, and the location in which the procedure is perfrmed. While a procedure's malpractice and work RVU's do not vary by location, CMS assigns different RVU's to many procedures when they are billed in a facility setting rather than an office setting. The sum of these RVU's are then multiplied by an RVU-to-dollar conversion factor to to generate the physician payment rate for a procedure. Thus, for procedure p in location l, the payment made under the Physician Fee Schedule is:[17][18]

$$PFS_{lp} = \left[RVU_p^{Work} + RVU_{lp}^{PE} + RVU_p^{MP}\right] ConvFac \tag{1}$$

where RVU^{Work} denotes work RVUs, RVU^{PE} practice xpense RVUs, and RVU^{MP} malpractice RVUs. *ConvFac* is the RVU-to-dollar conversion factor. All of these values are updated annually according to established CMS methodology that is described in the Federal Register.[19] For the purposes of this paper, I take RVU^{Work} and RVU^{MP} as given,

[15] These fees are occasionally updated mid-year. In years where there are multiple, I use the January MPFS file.

[16] For the purposes of this section, procedure will be used to mean CPT code.

[17] All RVU's are adjusted for geography, which I ignore for expositional purposes.

[18] Throughout the section, I ignore CMS's multiple rounds of budget balancing to ensure statutory spending requirements are met.

[19] See CMS-1403-FC for an example.

ignoring methodology for calculating them, as there are no substantive changes during this time period. Instead, I focus on variation in RVU^{PE} generated by CMS updating its estimates of practice expenses for providing procedures.

Practice expense RVU's can be decomposed into two portions: direct expense RVUs and indirect expense RVUs. Direct expense RVU's for each procedure are estimated by the American Medical Association (AMA) and may vary between office and facility settings. Indirect expenses assigned to a procedure are a multiple of its direct practice expenses. Each multiplier is calculated using survey estimates of the ratio of indirect to direct expenses for each specialty, where the multiplier is equal to the weighted average of the indirect-to-direct expense ratios for the specialties which perform the procedure.

From 1999 through 2009, CMS used estimates of these indirect-to-direct cost ratios from the AMA's Socioeconomic Monitoring System (SMS) survey, along with supplemental surveys from approximately a dozen specialties. These data had two large issues. First, by 2009, they were extremely out of date, having been collected from 1995-1999. To the extent the costs of practicing medicine (in particular, the ratio of direct to indirect costs) changed since the survey was conducted, they did not provide an accurate representation of the cost to physicians of providing service to patients. Second, the specialty data were extremely coarse. Supplemental data were provided to allocate specialty-specific costs to approximately 30 specialties, but many specialties did not have specialty specific cost data and were crosswalked to a similar specialty. To address both these concerns, CMS conducted the Physician Practice Information Survey (PPIS) from 2007-2008, which collected new data on the cost of providing medical service for many specialties. Expense ratio estimates under the PPIS were significantly different than the SMS for many specialties, which in turn generated large changes in the fees paid for many procedures. Of particular interest for this paper, procedures commonly performed by cardiologists were among the most affected by this update; for example, from 2009 to 2013, the payment rate for an echocardiogram performed in an office setting fell by 16%.

Many of the procedures which were subject to large fee reductions after the PPIS did not experience similarly large fee reductions when billed in a hospital outpatient department. For many procedures, CMS allows location-based billing. A procedure when performed in an office-setting would be paid PFS_{op} while that same procedure perfomed in a facility setting would be paid $PFS_{fp} + OPPS_p$ where PFS_{lp} is the PFS rate for procedure p in location $l \in \{\text{office, facility}\}$ and $OPPS_p$ is the payment for procedure p under the Outpatient Prospective Payment System (OPPS). Typically, it is more attractive to bill for a procedure in a facility setting, because total payments are higher, even though the cost of providing the procedure can be similar (or identical).[20] Since these total facility-based payments did not decrease as substantially, the relative gains to billing in a outpatient department increased for many cardiac procedures.[21]

Many observers, including the American College of Cardiology, predicted this would lead to rapid vertical integration in the cardiology specialty, as payments to cardiologists decreased and the relative value of working for a hospital increased. Consistent with this, cardiology experienced a large uptick in the percentage of procedures billed in an outpatient deparment (Song et al (2015)) and physicians directly employed by hospitals, rising from 8% in 2007 to 42% in 2017. (Nikpay et al (2018))

I define the price paid for procedure p in location l to be:

$$p_{lp} = \begin{cases} PFS_{op}, & l = \text{office} \\ PFS_{fp} + OPPS_p, & l = \text{facility} \end{cases} \tag{2}$$

[20]For example, in 2009, CMS paid 43.9% more for an echocardiogram performed in an outpatient department than an office based setting.

[21]In 2013, CMS paid 141% more for an echocardiogram performed in a facility setting than an office based setting.

I also define the facility markup for procedure p as

$$\eta_p := p_{fp} - p_{op}$$

The facility markup, η_p, is the additional amount of Medicare payments a physician could generate by billing for procedure p in a facility setting rather than an office based setting. Combining this with a physician's observed procedure mix, I calculate the mount of additional Medicare payments physician j could generate by shifting their billing entirely from an office-based setting to a facility-based one:

$$\pi_j := \sum_p \eta_p q_{jp}$$

where q_{jp} is volume of procedure p physician j performs. I collect data from CMS on prices paid for each procedure paid under the old survey (SMS) and the new survey (PPIS), which I use to estimate π_j under each survey, π_j^{new} and π_j^{old}, respectively. Given these, I estimate the amount physician j's benefit to billing in a facility changed as a result of the survey update as:

$$\Delta\pi_j := \pi_j^{new} - \pi_j^{old}$$

Intuitively, this is the amount the survey changed how much a physician could gain from billing entirely in a facility-setting. Key to the exogeneity of this variable is that the fee update is exogenous to a cardiologist's choice of treatment for a patient. This is for two primary reasons. First, as noted above, this change in the fee structure had no relationship to actual costs of doing business, since it was an update in the data collection. Second, the price CMS pays for a procedure is influenced by the costs of all specialties performing that procedure. In other words, updates in the cost estimates for radiology could affect the prices paid to cardiologists for a given procedure. Given that these are an entirely separate specialty of physicians, it is unlikely changes in their costs would affect cardiologists' practice of medicine.

In Figure 5, I explore the validity of this instrument, plotting the rate of integration by decile of $\Delta\pi$, which shows cardiologists in the top decile are more than twice as likely as those in the bottom decile to be integrated with a surgeon.

4.2 Predicted Integration

Given each physician's π_{jt}, I use a logistic regression to predict the probability a physician is integrated in quarter t. Formally, I estimate the logistic regression:

$$log\left(\frac{Pr[VI_{jt}=1]}{1-Pr[VI_{jt}=1]}\right)=\Delta\pi_{jt}+\gamma_t+\delta_{s(j)t}+\eta_{jt}$$

where $\delta_{s(j)t}$ and γ_t are state and time fixed effects, respectively. I then predict $\hat{VI}_{jt}$, which I use in an instrumental variables framework. Using the predicted probability of integration improves instrument strength over using π_{jt} directly in an IV framework. As described in (Wooldridge, 2010, p. 262-268), this is due to the binary nature of the endogenous regressor. When using π_{jt} directly, the first stage regression is a linear probability model, which is known to have worse fit than binary dependent variable regressions, such as the logistic regression. In this paper, this improves the strength of the instrument, providing more credible and precise estimates of β.[22]

[22] A similar approach is used and discussed in Adams et al. (2009).

4.3 Primary Estimating Equation

With the instrument in hand, I estimate the following regression:

$$Y_{ijt} = \beta VI_{jt} + \alpha X_{it} + \varepsilon_{ijt}$$

where X includes detailed patient and geographic controls as described in Section 3 along with quarter and state fixed effects.

5 Baseline Results

My empirical strategy reveals three facts about the effects of integration between cardiologists and surgeons. First, after integration, cardiologists shift patients from angioplasty and medical treatment to cardiac bypass. This does not improve patient hospitalization or mortality outcomes. Due to the shift from lower cost treatment options to surgery, total utilization for patients at vertically integrated cardiologists increases in the near-term. However, future spending is lower, largely due to lower risk of revascularization for medically treated patients.

5.1 Treatment Choices

Table 2 presents instrumental variables results from Equation (4.3) with the three treatment types (medical treatment, angioplasty, and surgery) as the dependent variables. Notably, the OLS and IV estimates of the effect of integration on treatment choice are not substantially different from one another. The physician fixed effects estimate of the effect of integration on the likelihood a patient receives CABG is 0.48*pp* in column (6) compared to 0.64*pp* from the IV in column (9). Though point estimates are different I cannot reject they are identical at reasonable confidence levels. Given the relatively low likelihood of CABG in the entire sample of 8.3%, an increase of 0.64*pp* is quite large, 7.7%.

An important consideration for the increase in CABG likelihood is where patients are redirected from. Cardiologists may be redirecting interventional patients away from angioplasty to CABG. Alternatively, they may shift more patients to CABG in total, without reallocating between interventional treatments. IV estimates in column (7) are 1.49*pp* less likely to be referred for medical management at integrated cardiologists. In contrast, I see no significant effect on the likelihood of receiving PCI. Though the point estimate of 0.852*pp* in column (8) is both large and positive, it is very imprecisely estimated, with a standard error of (0.681).

These findings show that integrated cardiologists do not reallocate patients between interventional treatments, rather they steer patients from the most conservative option into more intensive options. This is suggestive evidence that integrated cardiologists are not better informed about which patients would be most suitable for CABG. This stands in stark contrast to the findings of Afendulis and Kessler (2007) who found that interventional cardiologists steer patients towards PCI rather than both alternatives.

5.2 Patient Outcomes

The overall effect of steering patients to CABG on patient outcomes is unclear. Given the increased cost of CABG, it is expected overall medical spending will increase. However, if patients referred by integrated cardiologists have better access to surgery, they may experience better mortality and readmission rates.

In Table 3, I show that total 180-day spending increases, as should be expected from my estimates on treatment choices. In column (9), I show that integration increases patient medical spending by \$1,879 in the 180-days following diagnosis. This amounts to an increase of 7.8% in total medical spending. To put this into perspective, an increase of \$1,879 for each of the approximately 1 million catheterizations performed on Medicare patients each year would amount to an additional \$1.9*bn* in spending each year.

As described above, an increase in spending may be welfare enhancing if patient health outcomes improve as a result. However, in Table 4, I find that patients diagnosed by integrated cardiologists are, in fact, more likely to have an AMI readmission within 180-days. As in the case on treatment choices, this effect is consistent across identification strategies. In column (9), I estimate that patients diagnosed by integrated cardiologists are 0.51*pp*, or 13.4%, more likely to be readmitted for AMI between 30 and 180 days following diagnosis by an integrated cardiologist.

Similarly, I see substantially worse mortality outcomes for patients diagnosed by integrated cardiologists. In Table 5, I estimate that patients diagnosed by integrated cardiologists are 0.83*pp* more likely to die within 180-days of diagnosis. Again, this is a very large effect relative to the overall mortality rate, which is only 4.45%. Thus, my estimates imply an increase in mortality risk of 18.7%. In aggregate, this would translate into 8,300 additional deaths each year for Medicare catheterization patients.

On net, it is clear that patients diagnosed by cardiologists who are integrated with cardiac surgeons do not have improved outcomes. Instead, they have higher medical spending, despite having worse mortality and readmission outcomes.

6 Mechanisms

Though my results show a clear pattern of integrated cardiologists shifting patients to more intensive treatment options, increasing patient spending, and yielding worse mortality and readmission outcomes, it is unclear what mechanism drives these changes, which I address here. There are several possible explanations I explore.

6.1 Selection

The first possible explanation for my estimates is that cardiologists who are more likely to be integrated with surgeons diagnose different types of patients on unobservable dimensions, rendering my instrument invalid. While I cannot reject that patients differ on unobservable dimensions, I can show that patients do not differ along observable dimensions. I explore this possibility in Figure 6, which displays binned scatterplots of the Elixhauser risk score and predicted mortality risk[23] relative to predicted probability of integration. In Figure 6a, I examine the Elixhauser risk score, finding that, if anything, physicians who are highly likely to be integrated with a surgeon see healthier patients than others, though this effect is extremely small. From the fit line in this plot, moving from the 5th to the 95th percentile of predicted integration is associated with a lower Elixhauser risk score of approximately 0.2, while the standard deviation of risk scores in the overall sample is 9.36. In Figure 6b, I see a very similar pattern for predicted mortality.

6.2 Surgical Mortality Risk

Given that cardiologists who are very likely to be integrated do not have significantly different patient mixes from those who are less likely, the most immediate explanation for

[23] See Appendix C for details on the construction of this variable.

increased mortality is that coronary bypass simply has higher mortality risk than other treatment options. However, a simple back of the envelope calculations shows this is extremely unlikely. To illustrate, consider the expected mortality due to shifting patients to CABG:

$$\underbrace{(Pr[CABG|VI=1]-Pr[CABG|VI=0])}_{0.0064}\underbrace{\mathbb{E}[Death|CABG,VI=1]}_{0.062}\approx .0004 \tag{3}$$

The first term is the increase in the likelihood of CABG due to integration, which I estimate at 0.64*pp* in Table 2, while the second term is the average overall mortality for CABG patients diagnosed by integrated cardiologists. This yields an estimated increase in mortality of 0.04*pp* due to shifting patients to CABG. [24] Given that I estimate an increase in 180-day mortality of 0.83*pp*, shifting patients to CABG accounts for less than 5% of the increased mortality risk.

As an alternative to illustrate this point, I consider how large the increase in CABG likelihood would need to be in order to generate the observed increase in mortality. I do so by rearranging Equation (3) as follows:

$$(Pr[CABG|VI=1]-Pr[CABG|VI=0])=\frac{\mathbb{E}[Death|VI=1]-\mathbb{E}[Death|VI=0]}{\mathbb{E}[Death|CABG,VI=1]}$$

The right hand side of this equation is the increase in mortality associated with integration divided by the sample CABG mortality, which yields an estimate of 13.2*pp*. In other words, integrated cardiologists would need to be more than twice as likely to refer patients for coronary bypass than non-integrated ones, much larger than my estimates

[24]This likely is an overestimate of the increase in mortality due to shifting to CABG. The number calculated here would be the increase assuming patients who did not receive CABG had 0 mortality risk, while in reality they would have the mortality risk associated with the alternate treatment option they received.

suggest is reasonable. Considering the results of both of these calculations, I find no evidence to support the hypothesis that increased mortality risk is driven by higher propensity for surgery by integrated cardiologists.

6.3 Reputational Concerns

A further driver of mortality is that patients who are referred for surgery are lower risk, while patients who may benefit from surgery, but are at high mortality risk are not referred. This could occur due to cardiologists partially internalizing the downside risk of adverse patient outcomes on surgeon reputation. There is some evidence that surgeons reject risky patients to avoid negative shocks to their reputation (Jauhar, 2003), which could be internalized by referring physicians.

First, if this were the case, we should expect to see patients at high mortality risk be less likely to receive CABG at integrated cardiologists. As a first way to address this, I estimate a modification of Equation (4.3) by interacting the integration dummy with a dummy for whether a patient is high risk, which I define as having above median Elixhauser risk score. Formally, I estimate:

$$Y_{ijt} = \beta VI_{jt} + \delta(VI_{jt} \times HighRisk_i) + \gamma HighRisk_i + \alpha X_{it} + \varepsilon_{ijt} \tag{4}$$

where δ indicates how Y differs for high-risk patients diagnosed by integrated cardiologists. In column 1 of Table 6, I find that, while low risk patients are more strongly steered towards CABG by integrated cardiologists, patients in the high-risk category are no more likely to be referred to CABG by integrated cardiologists. This suggests that cardiologists are not internalizing the reputational risk of these patients.

Another way to consider this is to examine how the likelihood of a patient being referred for CABG differs in states where there are public report cards for surgeon mortality. If integrated physicians internalize reputational risks, we should expect to see high risk patients in states with report cards be less likely to receive CABG. These report cards are intended to inform patients about the quality of surgeons and have been the subject of much policy discussion and research. (Brown et al., 2012) I address this by modifying Equation (4) by interacting the high risk indicators with indicator variables for whether the physician is located in a state with report cards.[25][26]

$$Y_{ijt} = \beta VI_{jt} + \delta_1(VI_{jt} \times HighRisk_i) + \delta_2(VI_{jt} \times HighRisk_i \times ReportCard_{s(j)}) + \gamma_1 HighRisk_i + \gamma_2 HighRisk_i \times ReportCard_{s(j)} + \alpha X_{it} + \varepsilon_{ijt} \quad (5)$$

In column 2 of Table 6, I show that estimates of the likelihood of surgery do not differ for patients in these states relative to others. Given that I find no evidence that high risk patients are less likely to be referred for coronary bypass, even in the presence of public report cards, it is extremely unlikely that reallocating patients to avoid high risk patients is driving the observed mortality results.

6.4 Worse Care

The final remaining explanation I explore for mortality increasing is that care worsens conditional on treatment choice. In Table 7, I estimate Equation (4.3) on the subsample of patients receiving each treatment type. This tells us how mortality differs for patients diagnosed by integrated cardiologists conditional on the type of treatment they receive. In

[25] I do not include *ReportCard* on its own, as it is collinear with state fixed effects.

[26] There are five states which have cardiac surgeon report cards: California, Massachussetts, New Jersey, New York, and Pennsylvania.

column (1), I find that mortality increases substantially for medically managed patients, while PCI and CABG patients do not have statistically significant increases in mortality.[27] It's noteworthy that this result is similar in direction and magnitude to a result noted in Afendulis and Kessler (2007), who found an increase in mortality for medically managed patients diagnosed by an interventional cardiologist. They do not, however, attempt to explain the mechanism behind this result.

Intuitively, there are two possible explanations for increase in mortality for medically managed patients. First, riskier patients may be more likely to be steered towards medical management by integrated cardiologists. I repeat the exercise from Section 6.1 using only the sample of patients who are referred for medical management, finding no differences among patients along observable dimensions. These results are displayed in Figure 7. As in the overall sample, I see no meaningful relationship between the instrument and patient severity, as measured by predicted mortality and Elixhauser risk score. The fit line has a slight upward slope in both instances, however, the magnitude of this effect is extremely small - moving from the 5th to 95th percentile of the instrument is associated with an increase in risk score of less than 0.1. In addition, increasing the probability of integration by 0.50 increases the expected mortality risk by less 0.05*pp*.

In Table 8, I estimate Equation (4.3) with the number of Evaluation & Management visits a patient has within 180-days as the dependent variable on the sample of patients who receive medical management.[28] In column (1), I show that patients diagnosed by integrated cardiologists have 0.30 fewer visits for management services. I see a similar pattern in columns (2) and (3), when I split the sample by whether a patient survives 180-days or not. Among patients who die, those diagnosed by integrated cardiologists have significantly fewer (2.28) E&M visits.

[27] It should be noted that the point estimates of each represent economically significant increases in mortality, despite the lack of statistical power.

[28] I classify a claim as E&M if any procedure has a BETOS code beginning with "M".

These findings suggest integrated cardiologists do not provide effective management for conservatively treated patients, with patients having fewer routine management visits.

7 Conclusion

Financial integration of referring physicians with other healthcare providers shifts the treatment patterns of patients. My results here show that when a cardiologist works with a cardiac surgeon, they respond to the additional financial incentives provided by integration by referring more patients to coronary bypass. They do this primarily by referring fewer patients for medical management, the most conservative option, rather than reallocating intensively treated patients.

This reallocation of patients yields worse outcomes along with higher spending. Increased spending is relatively straightforward to diagnose, as it is driven almost entirely from shifting patients to more expensive treatment options. Because coronary bypass is significantly more expensive than either alternative, shifting patients towards it has large implications for total patient spending. However, it is much more difficult to diagnose the driver of increased mortality and hospitalization. My results suggest that lower quality care, in the form of less oversight of medically managed patients, is what drives worse quality for patients diagnosed by integrated cardiologists.

One of the most important findings of my paper is the stark contrast between difference-in-differences estimates of the effect of integration comared to the instrumental variables estimates. Difference-in-differences is an extremely common identification strategy in the literature on vertical integration, especially in the health care sector. However, my results show this strategy does not necessarily yield conclusions about the effects of integration which are consistent with other identification strategies.

Lastly, there are important policy implications of this study. While much of the literature has focused on price effects of vertical integration, my work adds to the growing body of literature showing that integration of health care providers can have significant effects on patient choices and outcomes, disregarding potential price effects.

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A Figures

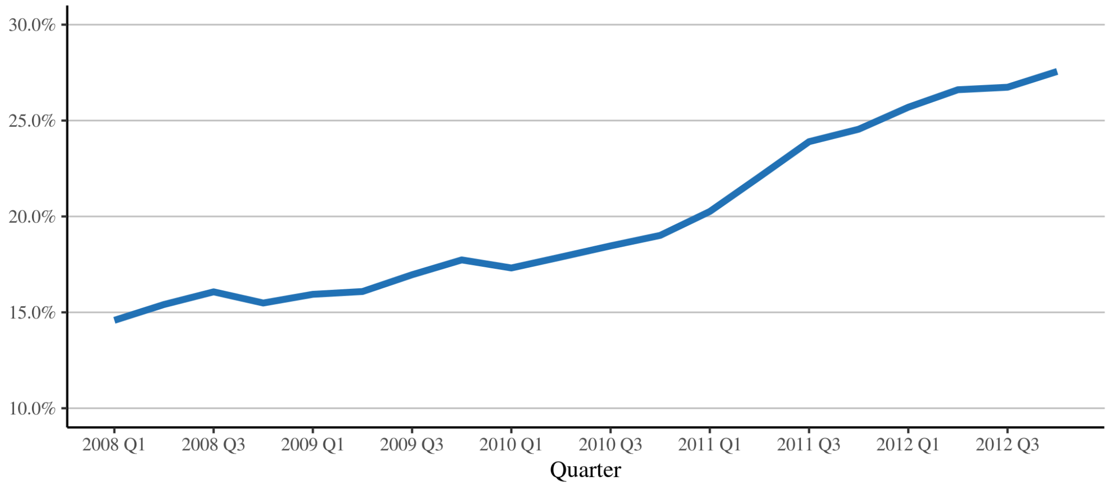


Figure 1: Share of Catheterizations Performed by Vertically Integrated Cardiologists

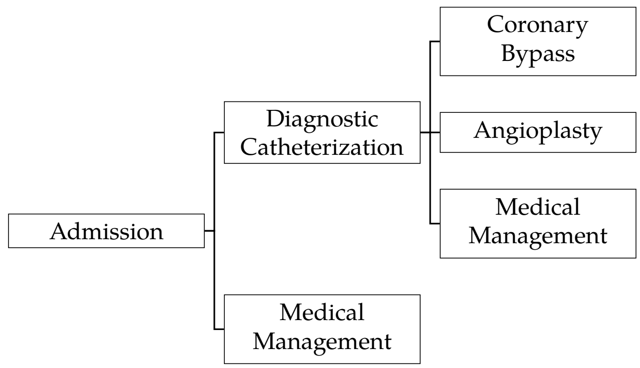


Figure 2: Cardiac treatment decision tree. Adapted from Cutler, McClellan, and Newhouse (2000).

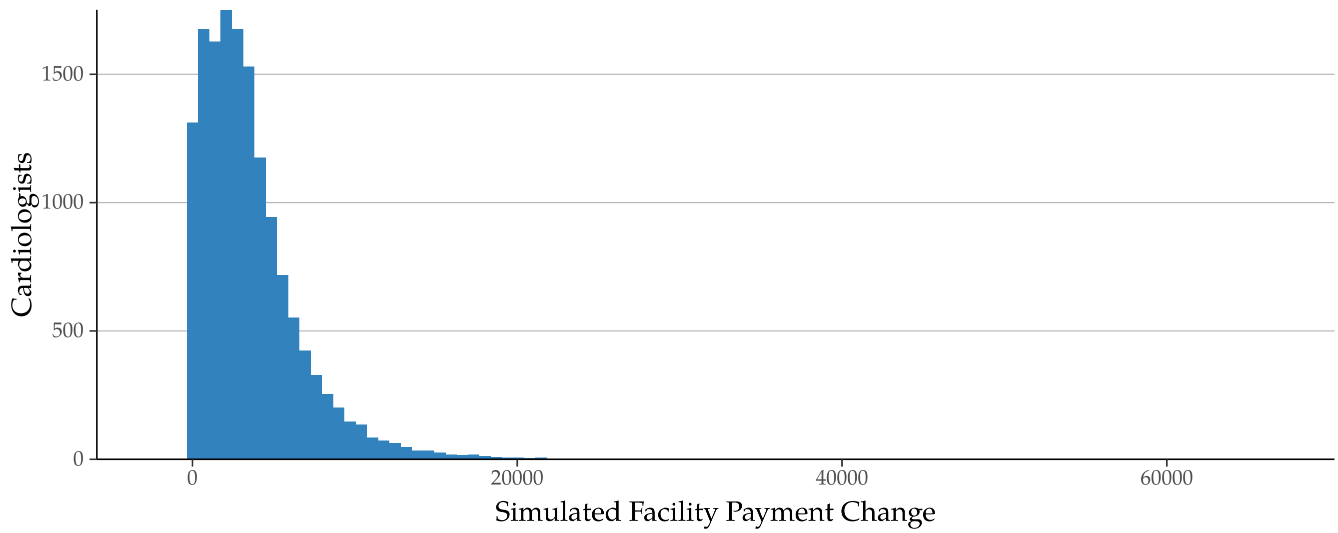


Figure 3: Distribution of Cardiologist Facility Payment Change

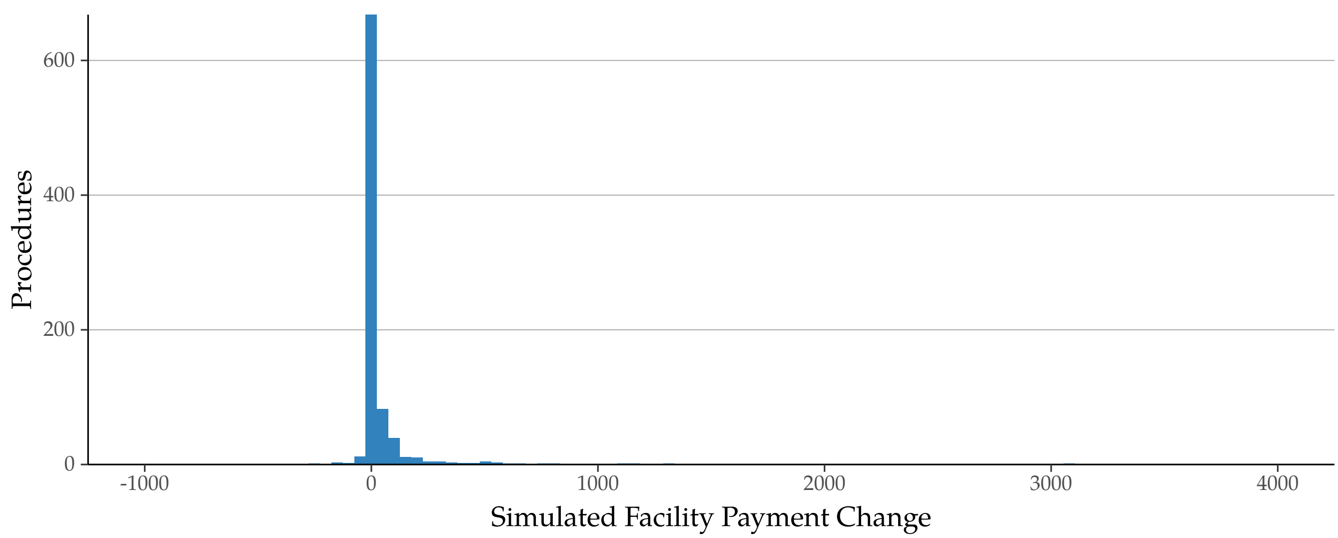


Figure 4: Distribution of Procedure Facility Payment Change

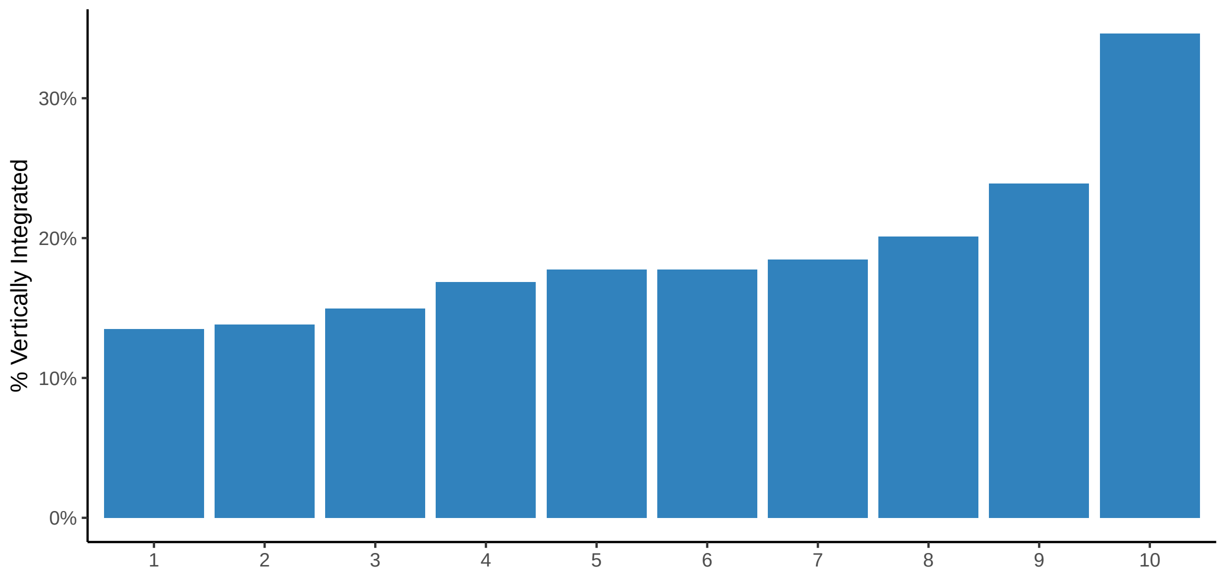
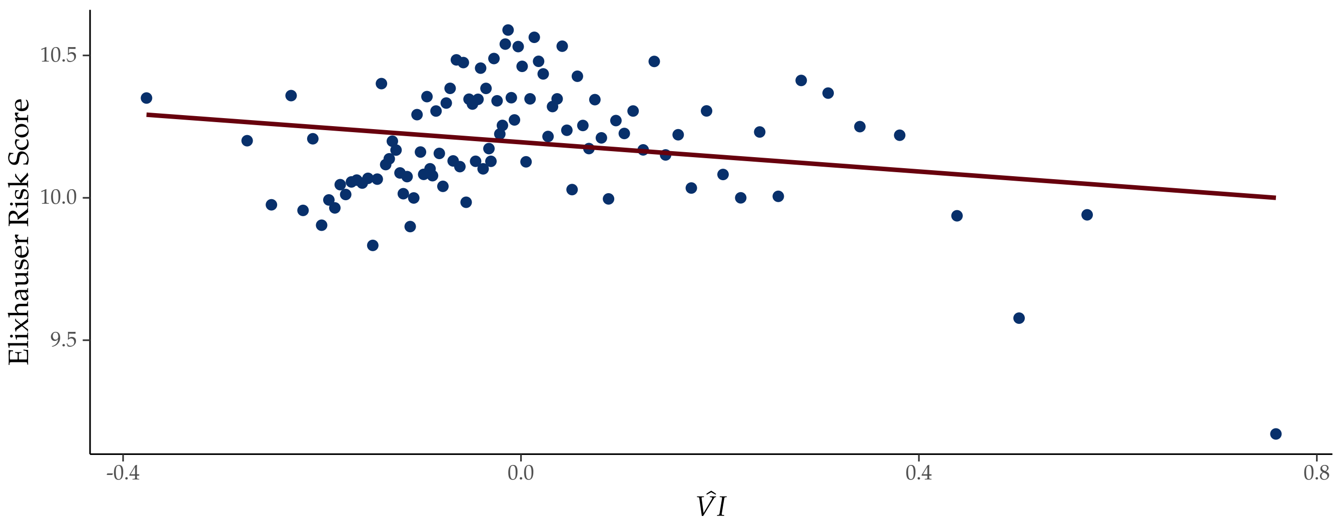
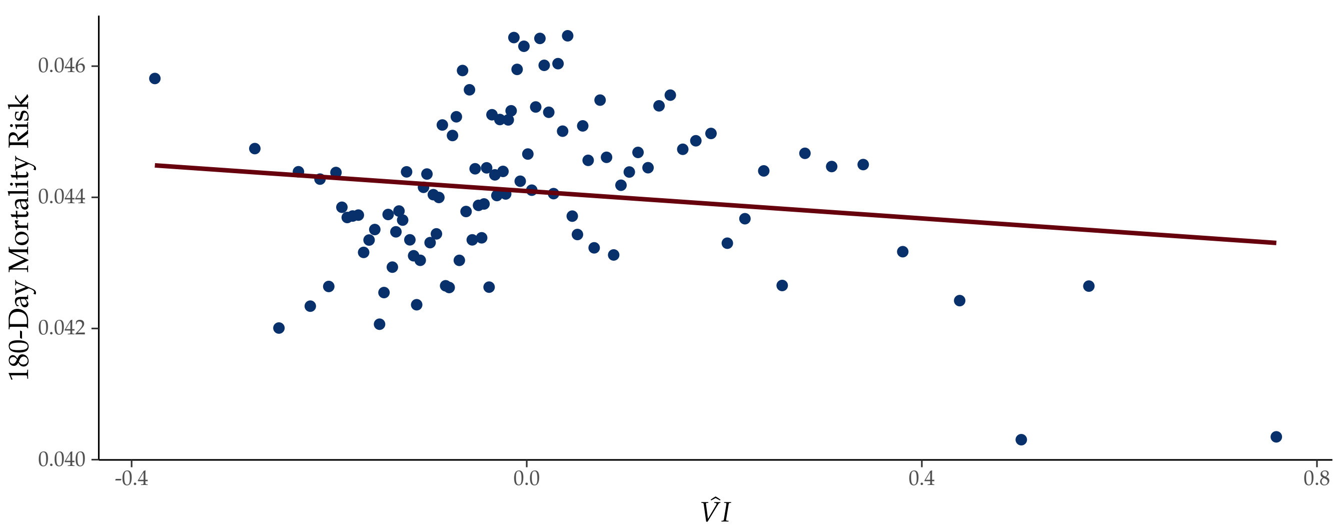


Figure 5: Share of Integrated Cardiologists by $\Delta\pi$ Decile

Notes: $\Delta\pi$ is the simulated change in a physician's facility markup, defined in Section 4.1.



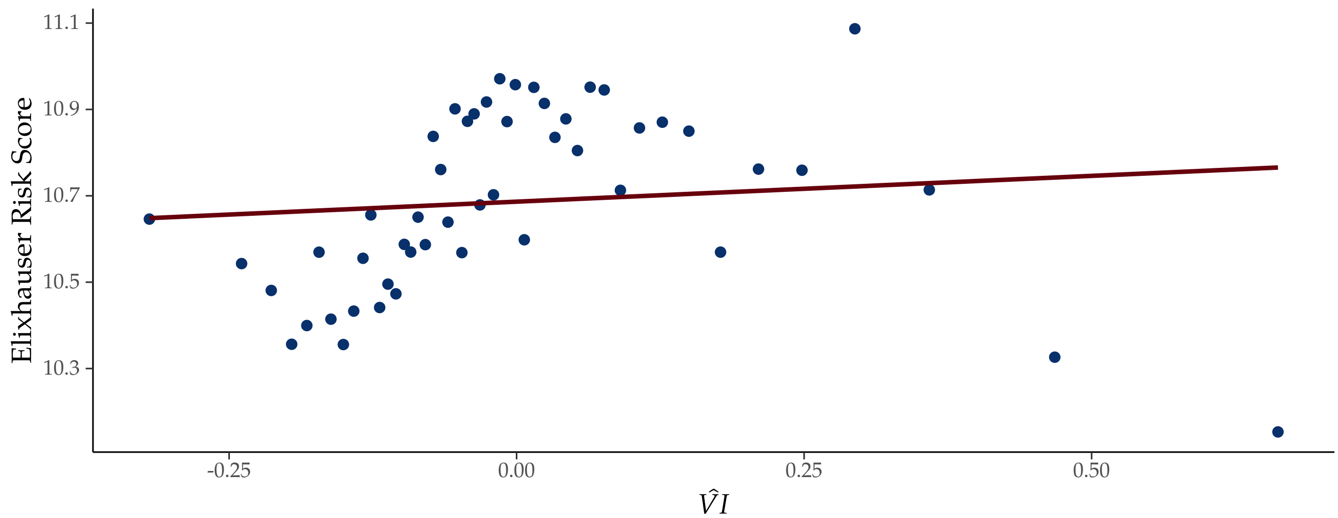
(a)



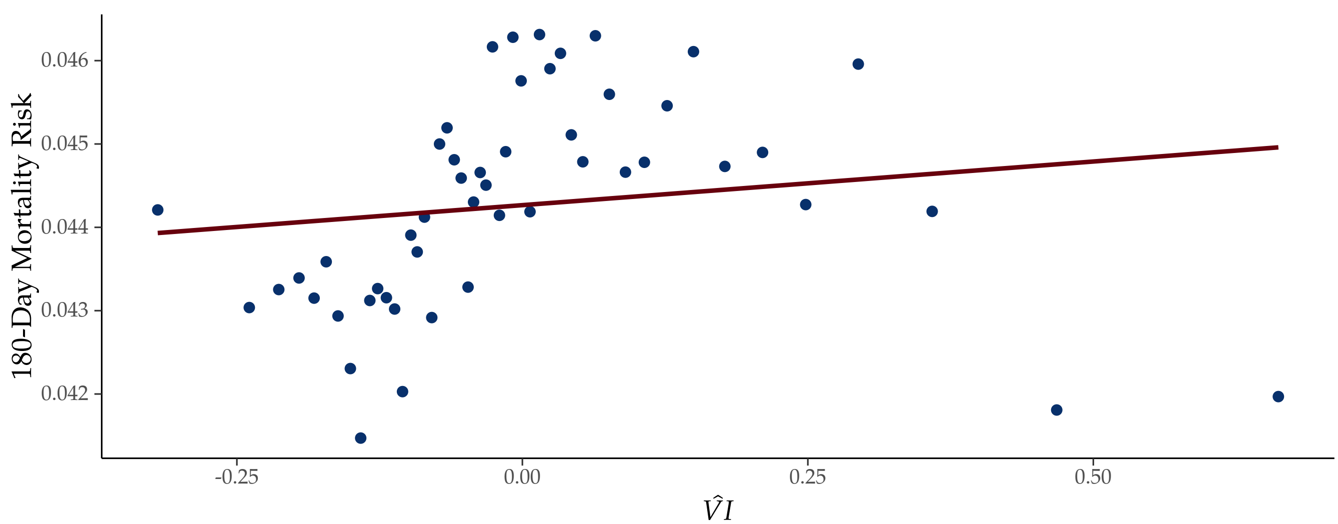
(b)

Figure 6: Binned Scatterplots of Patient Severity vs. Predicted Integration

Notes: All variables are residualized by state and quarter and grouped into 50 equally sized bins. $\hat{V}I$ is the predicted integration from Section 4.



(a)



(b)

Figure 7: Binned Scatterplots of Patient Severity vs. Predicted Integration - Medically Managed Patients

Notes: All variables are residualized by state and quarter.

B Tables

Table 1: Summary Statistics

Treatment	
Medical Management (%)	64.7
PCI (%)	27.0
CABG (%)	8.3
180-Day Outcomes	
Mortality (%)	4.5
Heart Attack Readmission (%)	3.8
Spending ($)	24,063
	(30,328)
Full Sample Observations	675,789
180-Day Sample Observations	589,166
Cardiologists	12,308
Cardiologist Switchers	2,115

Notes: An observation is a Medicare patient undergoing diagnostic catheterization. The 180-Day sample consists of patients who survive and are continuously enrolled in Medicare for 180 days following diagnosis. Switchers are those cardiologists who perform at least one in-sample catheterization before and after integrating with a surgeon.

Table 2: Effect of Vertical Integration on Treatment Choice

	OLS						IV		
	(1) Med.	(2) PCI	(3) CABG	(4) Med.	(5) PCI	(6) CABG	(7) Med.	(8) PCI	(9) CABG
VI	−0.522	0.285	0.237	−0.918*	0.460	0.459*	−1.491*	0.852	0.639*
	(0.318)	(0.331)	(0.132)	(0.381)	(0.375)	(0.197)	(0.654)	(0.681)	(0.300)
N	675,789	675,789	675,789	675,789	675,789	675,789	675,789	675,789	675,789
First Stage *F*							2,597	2,597	2,597
Treatment Mean	64.7	27.0	8.3	64.7	27.0	8.3	64.7	27.0	8.3
Quarter FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Physician FE				Y	Y	Y			

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. Dependent variable is 0 if the patient has no bypass claim and 100 otherwise. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Patients are matched to interventional treatments which occur within 1 month of their diagnosis. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. *VI* is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Physician-clustered standard errors are in parentheses.

Table 3: Effect of Integration on Medical Spending

	OLS						IV		
	(1) 60 Days	(2) 90 Days	(3) 180 Days	(4) 60 Days	(5) 90 Days	(6) 180 Days	(7) 60 Days	(8) 90 Days	(9) 180 Days
VI	$1,141^{***}$	$1,301^{***}$	$1,473^{***}$	112	98	8	$1,591^{***}$	$1,872^{***}$	$1,879^{***}$
	(126)	(139)	(163)	(167)	(189)	(238)	(240)	(267)	(301)
N	655,560	637,384	589,166	655,560	637,384	589,166	655,560	637,384	589,166
First Stage F							2,576	2,556	2,479
Spending Mean	18,072	20,041	24,063	18,072	20,041	24,063	18,072	20,041	24,063
Quarter FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Physician FE				Y	Y	Y			

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. Dependent variable is denominated in thousands of dollars. Observations for which the patient is not continuously enrolled in Medicare for the entire observation window or where the observation window extends past the end of the sample period are dropped. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. VI is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Physician-clustered standard errors are in parentheses.

Table 4: Effect of Integration on Readmission

	OLS						IV		
	(1) 60 Days	(2) 90 Days	(3) 180 Days	(4) 60 Days	(5) 90 Days	(6) 180 Days	(7) 60 Days	(8) 90 Days	(9) 180 Days
VI	0.124**	0.168**	0.273***	0.052	0.141	0.304*	0.219*	0.433***	0.510***
	(0.047)	(0.058)	(0.077)	(0.094)	(0.116)	(0.155)	(0.095)	(0.119)	(0.154)
N	656,501	641,691	605,144	656,501	641,691	605,144	656,501	641,691	605,144
First Stage *F*							2,571.776	2,557.997	2,496.149
Hospitalization Mean	1.7	2.5	3.8	1.7	2.5	3.8	1.7	2.5	3.8
Quarter FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Physician FE				Y	Y	Y			

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. *VI* is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Dependent variable is 100 if the patient has an inpatient claim within the observation window after discharge, 0 otherwise. Observations for which the patient is not continuously enrolled in Medicare for the entire observation window or where the observation window extends past the end of the sample period are dropped. Physician-clustered standard errors are in parentheses.

Table 5: Effect of Integration on Mortality

	OLS						IV		
	(1) 60 Days	(2) 90 Days	(3) 180 Days	(4) 60 Days	(5) 90 Days	(6) 180 Days	(7) 60 Days	(8) 90 Days	(9) 180 Days
VI	0.144**	0.168**	0.270***	0.046	0.032	0.040	0.380***	0.557***	0.830***
	(0.047)	(0.058)	(0.078)	(0.096)	(0.117)	(0.156)	(0.096)	(0.114)	(0.157)
N	663,810	651,110	614,158	663,810	651,110	614,158	663,810	651,110	614,158
First Stage F							2,584.872	2,566.310	2,498.844
Mortality Mean	1.8	2.6	4.4	1.8	2.6	4.4	1.8	2.6	4.4
Quarter FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Physician FE				Y	Y	Y			

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Dependent variable is 100 if the patient dies in the observation window after discharge, 0 otherwise. Observations differ from baseline due to excluding patients whose observation window extends past the end of the sample period. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. VI is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Physician-clustered standard errors are in parentheses.

Table 6: Reputational Effects

	(1) Med.	(2) PCI	(3) CABG	(4) Med.	(5) PCI	(6) CABG
VI	−2.895***	1.731*	1.164***	−2.650***	1.503	1.148**
	(0.702)	(0.728)	(0.347)	(0.740)	(0.770)	(0.369)
HighRisk	0.206	−0.223	0.017	−0.047	0.166	−0.119
	(0.217)	(0.205)	(0.126)	(0.234)	(0.221)	(0.133)
VI × *HighRisk*	3.087***	−1.932***	−1.155***	3.312***	−2.421***	−0.891**
	(0.551)	(0.526)	(0.301)	(0.587)	(0.558)	(0.317)
HighRisk × *ReportCard*				0.993*	−1.657***	0.664**
				(0.409)	(0.401)	(0.238)
VI × *ReportCard*				−4.556*	4.762*	−0.206
				(2.305)	(2.255)	(1.004)
VI × *HighRisk* × *ReportCard*				1.665	0.105	−1.770
				(1.982)	(1.962)	(1.116)
N	675,789	675,789	675,789	675,789	675,789	675,789
First Stage *F*	1,302.461	1,302.461	1,302.461	682.412	682.412	682.412
Treatment Mean	64.7	27.0	8.3	64.7	27.0	8.3
Quarter FE	Y	Y	Y	Y	Y	Y

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. *VI* is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Dependent variable is 100 if the patient receives coronary bypass, 0 otherwise. Observations for which the patient is not continuously enrolled in Medicare for the entire observation window or where the observation window extends past the end of the sample period are dropped. Physician-clustered standard errors are in parentheses.Estimates are from Equation (4) and (5), respectively. The instrument described in Section 4 is used to instrument for *VI* in all cases.

Table 7: Effect of Integration on 180-Day Mortality By Treatment

	180-Day Mortality		
	Med.	PCI	CABG
VI	0.61***	0.34	0.49
	(0.15)	(0.22)	(0.50)
N	396,585	166,092	51,481
First Stage *F*	2,603	2,157	2,442
Mortality Mean	4.47	3.91	6.05
Quarter FE	Y	Y	Y
Physician FE			

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. VI is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Dependent variable is 100 if the patient dies within 180 days of diagnosis, 0 otherwise. Observations for which the patient is not continuously enrolled in Medicare for the entire observation window or where the observation window extends past the end of the sample period are dropped. Physician-clustered standard errors are in parentheses.

Table 8: Effect of Integration on Evaluation & Management Visits For Medically Managed Patients

	(1) All	(2) Survivors	(3) Non-Survivors
VI	-0.30^{**}	-0.25^{*}	-2.28^{***}
	(0.11)	(0.12)	(0.58)
N	437,163	378,869	17,716
First Stage *F*	2,526	2,402	1,692
Visits Mean	6.39	6.25	13.35
Quarter FE	Y	Y	Y

Notes: *, ** and *** indicate significance at the 5%, 1% and 0.1% level, respectively. An observation is a Medicare patient undergoing cardiac catheterization. Only patients continuously enrolled in traditional Medicare for 12 months prior are included. Unreported covariates consist of sex and race dummies, a quadratic control for patient age, Elixhauser risk score, dummies for Elixhauser comorbidities, a dummy for history of myocardial infarction, a dummy for whether the diagnosing cardiologist performs PCI's, along with county level median age, income, and share of adults with college degrees. Comorbidities and risk score are calculated using the previous 12 months of claims. *VI* is a dummy for vertical integration. Vertical integration is defined as a cardiologist and surgeon working in the same practice. Dependent variable is medical spending after diagnosis in U.S. dollars. Observations for which the patient is not continuously enrolled in Medicare for the entire observation window or where the observation window extends past the end of the sample period are dropped. Physician-clustered standard errors are in parentheses.

C Predicted Mortality

To create a measure of predicted mortality, I estimate a logistic regression of 180-Day mortality on patient characteristics and use predicted values. Formally, I estimate:

$$log\left(\frac{Pr[Dies_{ijt}=1]}{1-Pr[Dies_{ijt}=1]}\right)=\alpha X_{ijt}+\eta_{jt}$$

where X includes the same patient controls as in the baseline analysis, excluding fixed effects. To avoid potential confounding from integration, I estimate this only on patients diagnosed by non-integrated cardiologists. Thus, this is a measure of a patient's mortality risk if they were diagnosed by a non-integrated cardiologist. Given these estimates, I use $\hat{Dies}$ as a measure of predicted mortality.

D CPT Codes

The following table lists all CPT codes used to identify procedures of interest.

Procedure	CPT Codes
Diagnostic Catheterization	93501, 93508-93529, 93451-93468
Percutaeneous Coronary Intervention	92980-92982, 92984, 92995-92996
Coronary Bypass	33510-33536, 33508, 33572