Three Essays on Payment Incentive Design, Health Care Delivery, and Quality Performance

by

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Abstract

Pay-for-performance programs intend to improve care through financial incentives. My dissertation focuses on payment incentive design, health care delivery, and quality performance.

Chapters 1-2 investigate the Hospital Readmissions Reduction Program (HRRP)'s intended and unintended ramifications. The HRRP aims to reduce readmissions through financial incentives. However, this well-intentioned policy has unintended consequences. The HRRP established different financial consequences for hospitals, depending on whether a patient was readmitted to the same (*index*) or to a different (*non-index*) hospital. Although readmissions to a *non-index* hospital rather than the *index* hospital have been pervasive, *only index* hospitals (*as defined relative to the given patient*) face *any* HRRP financial incentives to reduce readmissions. This increases risk of penalties and negative quality perceptions for *only* the *index* hospital — for readmission decisions outside their direct control. Consequently, *non-index* hospitals gain reimbursement for readmitting patients previously admitted elsewhere and avoid being penalized. This research is the first to exploit *exogenous variation* in hospital incentives to obtain *causal estimates* of the effects of the HRRP on patients, Medicare, and hospitals. There is variation in treatment of *index* versus *non-index* hospital visits from before to after the HRRP, along with variation in the magnitude of the hospital-specific marginal incentive. This research finds that providers are responsive to financial incentives underlying the specific HRRP design, responding more as incentives increase. Original admitting hospitals respond by decreasing the

probability of patients returning to any hospital, as the hospital-specific marginal incentive increases. Hospitals to which beneficiaries return respond by differentially increasing care through the ED, reducing readmissions, and decreasing spending for *index* hospital visits (compared to *non-index* visits) post-HRRP, as the marginal incentive increases.

This research sheds light on why overall readmission reductions have been less pronounced than expected, because readmissions at hospitals lacking financial incentives are common. These asymmetric incentives across hospitals influence revisits and readmissions, distort the signal of hospitals' readmission rates, increase unnecessary spending, and affect disparities.

Chapter 3 investigates whether changes in financial incentives to improve abdominal hysterectomy-based measure performance under the Hospital-Acquired Condition Reduction Program (HACRP) and the Hospital Value-Based Purchasing (HVBP) Program influence hysterectomy type as well as subsequent care and spending outcomes for patients. This research exploits variation in incentives from before to after HACRP and HVBP Program implementation and variation in the magnitude of the hospital-specific marginal incentive. Hysterectomies are the second most common surgical procedure for women. Compared with other types, *abdominal* hysterectomies have worse outcomes and higher spending. Beginning FY 2016, the HACRP and HVBP Program incorporated a surgical site infection following abdominal hysterectomy measure. Yet, because this is based only on *abdominal* hysterectomy performance, this changes the marginal incentives to select a given hysterectomy approach. This research finds that as providers face larger incentives to improve on the measure, the probability of performing an *abdominal* hysterectomy (rather than a *non-included* hysterectomy procedure) decreases.

Moreover, as the marginal incentive increases, the probability of patients receiving subsequent hospital care or having post-procedural expenses, along with the average post-hysterectomy price-standardized spending, decreases. The results inform policies about hysterectomy performance, hospital practices, and policy design. Together, this can lead to critical improvements in recovery, safety, and spending for the numerous patients undergoing hysterectomies each year.

Overview of Chapters 1-3

Using financial incentives, pay-for-performance programs aim to motivate providers to improve health care delivery. Created by the Affordable Care Act, the Hospital Readmissions Reduction Program (HRRP), the Hospital-Acquired Condition Reduction Program (HACRP), and the Hospital Value-Based Purchasing (HVBP) Program are mandatory programs that provide financial incentives to improve performance for targeted conditions or procedures. My dissertation investigates intended and unintended effects of health care payment policy design. In particular, the three chapters of my dissertation focus on payment incentive design, health care delivery, and quality performance.

The first two chapters investigate some of the HRRP's intended and unintended ramifications. Readmissions are pervasive and expensive. They affect over 2 million patients and cost more than $25 billion every year to Medicare. The HRRP seeks to reduce 30-day readmissions for targeted conditions through financial incentives. However, this well-intentioned policy has unintended consequences. The HRRP established different financial consequences for hospitals, depending on whether a patient was readmitted to the same (*index*) or to a different (*non-index*) hospital. If a patient returns to the *index* hospital and gets readmitted, the *index* hospital is at risk of getting penalized. The penalty for each excess readmission of a patient with a heart failure, hip replacement, or knee replacement index admission is approximately five to twenty times larger than the reimbursement from the initial admission (Medicare Payment Advisory Commission, 2018). Consequently, the *index* hospital faces an incentive to curtail readmissions and instead treat patients through the ED or an observation stay. In contrast, the

non-index hospital (*as defined relative to the given patient*) does *not* have any financial incentive to reduce readmissions. As a result of readmitting such patients, its readmission rate is unaffected, while the *index* hospital's rate gets worse, and it is at risk of penalties and negative quality perceptions as a result of readmission decisions outside its direct control.

This research is the first to exploit *exogenous variation* in hospital incentives to obtain *causal estimates* of the effects of the HRRP on patients, Medicare, and hospitals. There is variation in treatment of *index* versus *non-index* hospital visits from before to after the HRRP, along with variation in the magnitude of the hospital-specific marginal incentive. The marginal incentive measures how much an improvement in the condition-specific readmission would affect performance, and subsequently Medicare reimbursement. Furthermore, this research focuses on acute myocardial infarction (AMI) beneficiaries under the HRRP overall and then restricts to patients who return to any hospital by ambulance within 30 days, where hospital choice is effectively randomized by ambulances, using an instrumental variables approach.

Using national Medicare claims data, this research quantifies the extent to which such differential incentives affect outcomes and, in turn, makes significant policy recommendations. Chapter 1 investigates the following questions. First, it investigates whether the probability of patients returning to *any* hospital within 30 days of an AMI HRRP initial admission (regardless of whether they were readmitted) changed as a function of the hospital-specific marginal incentive for improvement on the AMI measure following HRRP implementation. Second, among patients who return to *any* hospital within 30 days, this research investigates whether the return hospitals' decisions to readmit the given patient differentially changed for patients returning to the same (index) hospital compared to patients returning to a different (non-index) hospital (as defined relative to the given patient), from before to after HRRP implementation,

and whether this effect increased with the hospital-specific marginal incentive for improvement. Third, this research tests how differing incentives for index and non-index hospitals affect patient outcomes, Medicare spending, and reported hospital quality measures, conditional on whether returning patients return to an index versus non-index hospital. There are two explanatory measures of interest. The first reflects whether there is a difference between index and non-index hospitals after HRRP implementation, for hospitals with zero financial marginal incentive for improvement under the HRRP, but who are still subject to public reporting of performance. This reflects a difference-in-differences model. The second reflects whether the treatment effect increases with the hospital-specific marginal incentive. This is a difference-in-difference-in-differences model. The treatment effect refers to whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation.

Chapter 2 builds on Chapter 1. Using national data, this research investigates whether the HRRP alleviated or exacerbated disparities in key outcomes. For each outcome, this research investigates whether there was heterogeneity in the treatment effect by patient race or safety-net hospital status. Specifically, for minority patients (compared to non-minority patients) or safety-net hospitals (compared to non-safety-net hospitals), it estimates the differential change in the outcome for patients returning to index versus non-index hospitals, from before to after HRRP implementation, and how this effect increased with the marginal incentive for improvement.

Together, the first two chapters find that providers are responsive to financial incentives underlying the specific design of the HRRP, responding more as the financial incentive to respond increases. In particular, the original admitting hospitals respond by decreasing the probability of patients returning to any hospital within 30 days, as the hospital-specific marginal incentive increases. Hospitals to which beneficiaries return within 30 days respond by

differentially increasing care through the ED, reducing readmissions, and decreasing spending for *index* hospital visits (compared to *non-index* hospital visits) post-HRRP, as the hospital-specific marginal incentive increases.

Among hospitals characterized as *non-safety-net* over this time period, Non-White patients were more likely than White patients *within* the given hospital, prior to HRRP implementation, to return to a hospital within 30 days. Yet, this within-hospital difference narrowed following HRRP implementation. This may be due to allocating limited resources to trying to prevent hospital revisits among patients perceived to be at highest risk, such as minority patients. To the extent that this has been achieved through positive changes, such as improved discharge processes and follow-up, this narrowing disparity may signal improved patient outcomes and care delivery. Responsiveness in reducing this racial disparity post-HRRP implementation did *not* appear to increase with increases in the marginal incentive to improve.

Evidence from this research sheds light on why overall readmission reductions have been less pronounced to date than expected because many return hospital visits are *not* subject to financial incentives. These asymmetric incentives across hospitals influence hospital revisits as well as readmissions, distort the signal of hospitals' readmission rates, increase unnecessary spending, and affect disparities.

This research emphasizes the potential for policy refinement to improve societal outcomes. The HRRP could be refined to more explicitly incentivize and reward reducing revisits to any hospital within 30 days (regardless of readmission). This is particularly critical because investments in effort to curtail revisits can be costly in terms of time and resources. This limits the capacity of lower-resourced hospitals, such as safety-net hospitals, to implement such changes. Moreover, curtailing revisits that would result in: (1) care provided through the ED (but

not readmissions) at *index* hospitals with an incentive to improve or (2) *any* care at *index* hospitals with *zero* incentive sacrifices the given *index* hospital's revenue without producing rewards. Instead, explicitly rewarding decreases in the probability of patients returning to any hospital could incentivize investments in effort to curtail revisits and, in turn, readmissions. Additionally, separately reporting and calculating performance on (1) revisits to any hospital, (2) readmissions at index hospitals, and (3) readmissions at non-index hospitals would reduce distortions in the current overall readmission measure and provide clarity on performance that the index hospital has more control over. Furthermore, if *all index and non-index hospitals* were subject to at least some incentive to curtail readmissions, this would (1) diminish distortion in reported performance, (2) reduce penalties based on decisions outside the index hospital's direct control, and (3) further incentivize and reward efforts to curtail readmissions. These changes could lead to imperative improvements in readmission reductions, quality, and patient safety across hospitals, thereby impacting millions of lives.

Chapter 3 investigates whether changes in financial incentives to improve abdominal hysterectomy-based measure performance under the Hospital-Acquired Condition Reduction Program (HACRP) and the Hospital Value-Based Purchasing (HVBP) Program influence type of hysterectomy as well as subsequent care and price-standardized spending outcomes for hysterectomy patients. This research not only exploits variation in incentives from before to after HACRP and HVBP Program implementation, but it also exploits variation in the magnitude of the hospital-specific marginal incentive. With approximately 600,000 performed annually, hysterectomies are the second most common surgical procedure for women. Compared with other hysterectomy types, abdominal hysterectomies have worse patient outcomes and higher health care spending. Beginning FY 2016, both the HACRP and the HVBP Program have

incorporated a measure of surgical site infection following abdominal hysterectomy (even among non-Medicare patients) into the set of measures for which hospitals are rewarded or penalized. Yet, because this measure is based only on performance on *abdominal* hysterectomy, this changes the marginal incentives to select a given hysterectomy approach across patients.

This research finds that as providers face larger incentives to improve on the hysterectomy-based measure, the probability of performing an *abdominal* hysterectomy (rather than a *non-included* hysterectomy procedure) decreases. Moreover, as the hospital-specific marginal incentive increases, the probability of patients receiving subsequent hospital care or having post-procedural expenses, along with the average post-hysterectomy price-standardized spending, decreases. Together, this may be due to providers shifting to non-included hysterectomy procedures, which carry less risk of adverse patient outcomes, as well as efforts to reduce risk of a post-procedure infection across all procedure types.

This research highlights the role for policy refinement to further improve societal outcomes. As noted, the financial incentives do *not* explicitly incentivize efforts to prevent infections among patients who receive a non-included hysterectomy. Yet because surgical site infections can also occur for non-included procedures and contribute to patient morbidity and mortality, it is crucial to better track and incentivize reductions of infections from non-included procedures as well. However, this should be done in a way that does *not* undermine incentives to substitute towards such *non-included* types. Indeed, policy could even be further refined to provide some financial incentive to shift towards *non-included* hysterectomy types among hospitals facing zero marginal incentive to improve on the hysterectomy-based measure. Together, these changes could lead to vital improvements in patient recovery, safety, and overall health care spending for the numerous patients undergoing hysterectomies each year.

Chapter 1: Evaluating Effects of Differing Hospital Readmissions Reduction Program Incentives on Hospital, Medicare, and Patient Outcomes

1.1 Introduction

Hospital readmissions are pervasive and expensive (Jencks, Williams, Coleman, 2009), affecting over 2 million patients and costing more than $25 billion every year to Medicare. Not only do preventable readmissions expose vulnerable patients to additional procedures and increased hospital stays, but they also undermine health care quality. Prior to the Affordable Care Act, approximately 1 in 5 Medicare fee-for-service (FFS) beneficiaries who had an acute myocardial infarction (AMI) admission were readmitted to a hospital within 30 days (Dharmarajan et al., 2013). Moreover, patient readmissions to a different (*non-index*) hospital within 30 days of an initial admission historically have been pervasive, representing over 25 percent of readmissions in the case of AMI patients (Hasan et al., 2020; Rymer et al., 2019).

Pay-for-performance programs intend to improve care through financial incentives. The Hospital Readmissions Reduction Program (HRRP) is a mandatory program created by Section 3025 of the Affordable Care Act to provide financial incentives to reduce hospital readmissions for targeted conditions. Under the program, all admissions are classified as either an index admission (which begin a window of accountability) or a readmission (an admission to any hospital within 30-days of discharge from an initial admission). The extent to which providers are responsive to the underlying incentives and the extent to which all providers face such incentives can both matter in determining the effect of the HRRP. Yet, while readmissions to a different (*non-index*) hospital than the *index* hospital historically have been pervasive, *only index*

hospitals face financial incentives under the HRRP to avoid readmitting the given patient. *[Note that throughout the paper, hospitals are referred to as index or non-index hospitals for simplicity. However, it is important to keep in mind that this is referring to index versus non-index visits, since index/non-index status is always implicitly defined relative to the given patient. Most hospitals are both index and non-index hospitals over a year, but they are always ONLY one or the other for any specific patient.]*. This stems from the HRRP's treatment of readmissions to *non-index* hospitals. *Non-index* hospital admissions within 30 days of an initial admission are attributed *only* to the *index* hospital's readmission statistics (Rau, 2019; CMS). This thereby increases the risk of financial penalties and negative quality perceptions for *only* the *index* hospital — for readmission decisions outside of their direct control. With considerable spending at stake, even small percentage reductions to the base payment amount because of penalization can reflect meaningful losses in reimbursement. Because readmissions at *non-index* hospitals are common, a considerable number of readmissions are to hospitals lacking financial incentives to curtail such readmissions.

This is the first study to exploit exogenous variation in incentives introduced by distinct treatment of index versus non-index hospital visits to address critical unanswered questions about the effects of readmission incentive design on patients, Medicare, and hospitals. Specifically, it is the first study to exploit exogenous variation in incentives — variation in treatment of index versus non-index hospital visits from before to after the HRRP, along with variation in the magnitude of the hospital-specific marginal incentive — to obtain causal estimates. This research builds on prior research that has found that while readmissions have decreased post-HRRP implementation (Wasfy et al., 2017; Angraal et. al., 2018; Zuckerman et al., 2016; Medicare Payment Advisory Commission, 2018), a substantial portion of these

reductions can be explained by hospital upcoding, increasing patients' coded level of severity, which artificially lowers hospitals' 30-day risk standardized readmission rates without *true* readmission reductions (Ibrahim et al., 2018; Ody et al., 2019; Gupta, Fonarow, 2018; Wadhera, Yeh, Joynt Maddox, 2019). Consequently, new national empirical evidence from this study could further shed light on why *overall true* readmission reductions have been less pronounced to date than expected (Ibrahim et al., 2018; Ody et al., 2019; Gupta, Fonarow, 2018; Sandhu, Heidenreich, 2019; Samsky et al., 2019), since patient readmissions at hospitals lacking financial incentives to curtail readmissions are common.

Moreover, while there are concerns about possible unintended consequences from the specific design of pay-for-performance incentives (Gupta, Fonarow, 2018; Wadhera, Yeh, Joynt Maddox, 2019; Huckfeldt et al., 2019; Wadhera et al., 2018; Samarghandi, Qayyum, 2019; Gupta et. al., 2018; Albritton, Belnap, Savitz, 2018; Puebla Neira et al., 2020; Nathan et al., 2020; Albritton, Belnap, Savitz, 2017; Wadhera et al., 2019; Krumholz, et. al., 2013; Chatterjee, Joynt Maddox, 2018; Fonarow, Ziaeian, 2019; Gupta, Fonarow, 2018; Jha, 2018; Huckfeldt et al., 2018; Fuller et al., 2018), such concerns have not yet been fully investigated in the context of revisits to index versus non-index hospitals (as defined relative to the given patient) before and after HRRP implementation. It is important to account for whether the given hospital would be penalized for its readmission decision, due to its index or non-index status. Investigating concerns *overall* across hospitals masks critical heterogeneity across index and non-index hospitals. Such concerns can directly affect the quality, safety, accessibility, affordability, and equity of health care.

Together, these asymmetric incentives have critical implications for patients, hospitals, and Medicare. First, this creates unequal comparisons across hospitals. Certain hospitals are

disproportionately affected because their patients disproportionately visit non-index hospitals after an initial admission, and non-index hospitals lack incentives to avoid readmitting those patients. This, in turn, affects reported *index* hospital performance under the HRRP. Consequently, the hospitals disproportionately affected will be at increased risk of suffering from perceptions of lower quality performance and being penalized financially for readmission decisions outside of their direct control. This can create disparities across hospitals with long-lasting financial and quality perception ramifications.

Second, this may distort the publicly reported hospital readmission measures. This undermines the aims of publicly reporting HRRP performance: (1) to provide quality of care information to patients to reduce asymmetric information between patients and providers, enabling patients to make informed health care decisions, as well as (2) to incentivize improvements in quality across providers by introducing quality competition. As a result, this negatively affects patients who rely on these measures to inform medical decision-making but instead receive misleading quality information.

Third, this may also change incentives for providers to curtail readmissions. This is because the measures also reflect hospital readmission decisions at *other* hospitals. For example, hospitals disproportionately affected by patients returning to other hospitals may feel their decisions to avoid readmitting their index patients would not sufficiently change whether the given hospital is penalized due to that measure performance, given lack of incentives at other hospitals and how penalties are calculated *(see Equation 1 on page 9)*. As a result, they may feel less pressured to curtail readmissions, particularly since such efforts may be costly in terms of time and resources. On the other hand, some index hospitals may put even more effort into

reducing the likelihood that they readmit their index patients because there are fewer patients for which they have direct control over the readmission decision.

This research is significant because it shows how differing incentives influence hospital readmissions, distort the signal of hospitals' readmission rates, increase unnecessary spending, and increase disparities. This research quantifies the extent to which such differential incentives affect outcomes, and in turn, makes significant policy recommendations to address concerns. This is vital to improve provider competition on quality as well as help patients who rely on quality measures to inform medical decision-making. In turn, insights gained from this research can further improve urgently needed readmission reductions, Medicare savings, and quality, while reducing disparities across hospitals, thereby affecting millions of lives.

1.2 Conceptual Framework

For illustration, consider the hypothetical cases of Angela and Barbara, both of whom are in their late 60's and live closest to *Hospital A* in a small city with two hospitals. Angela suffered an acute myocardial infarction and was rushed to *Hospital A.* After being treated during the hospital admission, she was discharged and returned home. Two weeks later, she suffered similar symptoms and quickly returned to *Hospital A*. Based on her severity, her case allowed discretion on the part of the hospital to which she returned about whether to admit her. Because she was recently admitted there, *Hospital A* providers instead kept her overnight in an observation stay and then sent her home. Because she was not readmitted, this case did *not* count against *Hospital A* in the Hospital Readmissions Reduction Program.

Barbara also suffered an acute myocardial infarction, but she was rushed to *Hospital B* because she had been visiting a friend in that area. She returned home after being discharged

from Hospital B. Two weeks later, she experienced similar symptoms and quickly went to *Hospital A* because it was closest. Like Angela, based on her severity, Barbara's case allowed discretion on the part of the hospital to which she returned about whether to admit her. Because she had *not* previously been admitted there, *Hospital A* providers were *not* concerned about avoiding a readmission, and consequently admitted her. However, because she was recently admitted elsewhere, this second admission counted as a readmission against *Hospital B (and not Hospital A)*. As a result of this case, *Hospital B's* readmission rate got worse. In contrast, *Hospital A* benefited from the higher reimbursement from an admission, without any risk of being penalized due to this case.

The HRRP decreases payments applied to all Medicare fee-for-service (FFS) base operating diagnosis-related group (DRG) payments for hospitals deemed to have excessive 30-day readmissions for targeted conditions or procedures. The HRRP was created by the ACA, but the final details were not formally announced until the August 2011 Federal Register Final Rule. Although penalties began FY2013, penalties were calculated based on prior performance, so hospitals had an incentive to react immediately to the 2011 announcement. The applicable conditions and procedures initially included acute myocardial infarction, heart failure, and pneumonia, constituting over 10 percent of Medicare inpatient stays and some of the most expensive conditions (Liang, Moore, Soni, 2020), and have since expanded to include chronic obstructive pulmonary disease (COPD), hip or knee replacement, and coronary artery bypass graft (CABG) surgery. These procedures are among the most frequent surgeries overall, with hip and knee replacement as the most common surgeries for Medicare beneficiaries (CMS). They also reflect some of the most expensive procedures (McDermott, K.W. & L. Liang, 2021). Additionally, the maximum penalty has increased from 1% of all of a given hospital's Medicare

FFS base payments in FY 2013, to 2% in FY 2014, and then to 3% in all subsequent years. Most recently, the 21st Century Cures Act changed the payment reduction methodology from a non-stratified methodology (FYs 2013-2018) to a stratified methodology (FY 2019 and onward), meaning that the given hospital's performance is assessed relative to hospitals with a similar percentage of patients who are dually eligible for Medicare and full Medicaid benefits (CMS).

Equations 1 and 2 show the HRRP formulas used to calculate the percent (*P*) of DRG payment that the hospital will receive after subtracting the HRRP-specific penalty (Centers for Medicare & Medicaid Services, 2017).

Equation 1 reflects the equation under the original HRRP methodology.

$$(1) \qquad P = 1 - min\left\{.03, \sum_{dx} \frac{Payment_{dx} \times \mathbf{1}(\#Discharge_{dx} > 24) \times max\{(ERR_{dx} - 1), 0\}}{All\ Payments}\right\}$$

Equation 2 reflects the equation under the revised, stratified HRRP methodology.

$$(2)\ P = 1 - min\left\{.03, \sum_{dx} \frac{(Neutrality\ modifier) \times Payment_{dx} \times \mathbf{1}(\#Discharge_{dx} > 24) \times max\{(ERR_{dx} - peer\ group\ median\ ERR), 0\}}{All\ Payments}\right\}$$

In the equations, *dx* reflects the HRRP-targeted condition or procedure, payments refer to base operating DRG payments, and ERR refers to the hospital's condition-specific excess readmissions ratio, which captures its performance on the given measure. The numerator of the ERR reflects the *actual adjusted number of readmissions* for that hospital. It is calculated by estimating the probability of readmission for each patient who qualifies for that measure at that hospital and summing up these probabilities over all these patients. The denominator of the ERR reflects the *expected number of readmissions*. It is calculated by summing the probability of readmission for these same patients as if they were treated at an average quality hospital. Therefore, readmission measure results reflect the given hospital's performance compared to the

performance of an average hospital treating comparable patients. Approximately half of hospitals will have higher actual adjusted readmission rates than expected readmission rates for a given condition or procedure each year, and therefore receive a penalty. CMS uses a rolling three-year performance period to calculate readmission measures (Maurer, Peris, Bunch, 2020). As a result, hospitals have an idea of how well they are performing and their expected readmissions over time.

Also as reflected in the equation, any condition or procedure with an ERR of 1 or less will drop out of the equation, since the hospital performed as well or better than expected on the given measure. Additionally, only measures based on more than 24 discharges for the given condition or procedure are included for the given hospital. As shown here, the overall penalty is capped at 3 percent in later years (while it was smaller in earlier years). Under the revised, stratified HRRP methodology, the dual eligible proportion is calculated for each hospital. Hospitals are then stratified into 5 peer groups, and the median ERR for the given peer group enters the equation. The neutrality modifier refers to the factor that equates payments under the stratified methodology to payments under the unstratified methodology.

Yet, despite the well-intentioned goals of the HRRP, the HRRP has unintended consequences. It established different financial consequences depending on whether patients are readmitted to the same (*index*) or to a different (*non-index*) hospital. Figure 1.1 below presents the asymmetric financial incentives that an index hospital faces relative to a non-index hospital. To quickly visualize this, the red color highlights incentives for the index hospital to avoid excess readmissions, while the blue color highlights incentives towards a given care decision for each type of hospital. If a patient returns to the *index* hospital within 30 days and gets readmitted, the *index* hospital is at risk of a penalty and negative quality perceptions. The penalty for each

excess readmission of a patient with a heart failure, hip replacement, or knee replacement initial admission, is approximately *five to twenty times larger* than the reimbursement from the initial admission (Medicare Payment Advisory Commission, 2018). Therefore, for *index* hospitals after HRRP implementation, any positive direct financial incentive to admit such patients is undermined by the negative indirect financial incentive (i.e., decrease in all Medicare FFS payments for their hospital as a result of excess readmissions of such patients). If the *index* hospital instead treats the given patient through the emergency department or an observation stay, however, this does *not* count against the *index* hospital. Consequently, the *index* hospital faces an incentive to curtail readmissions, and instead treat the given patient through the emergency department or an observation stay.

In contrast, if a patient returns to a *non-index* hospital within 30 days, the *non-index* hospital has *no* financial incentive to avoid a readmission. Instead, the *non-index* hospital can readmit *all* such patients with *zero* risk of penalty or negative quality perceptions. As a result, the *non-index* hospital not only gains reimbursement for readmitting such patients (positive direct financial incentive), but it also avoids a decrease in all Medicare FFS payments from excess readmissions of such patients (non-negative indirect financial incentive). Put another way, if the *non-index* hospital instead *avoids* the given readmission, it would incur the cost of foregoing that readmission *but not* gain any benefit in terms of improved reported performance or avoided penalties for that hospital, *unlike index* hospitals. As a result of readmitting the given patient, the *non-index* hospital gains higher reimbursement through the readmission (compared to treating patients through the emergency department or an observation stay) and its reported readmission rate is unaffected. In contrast, the readmission rate for the *index* hospital gets worse and the *index*

hospital is at risk of a penalty and negative quality perceptions — for a readmission decision outside of its direct control and *not* subject to any financial incentives under the HRRP.

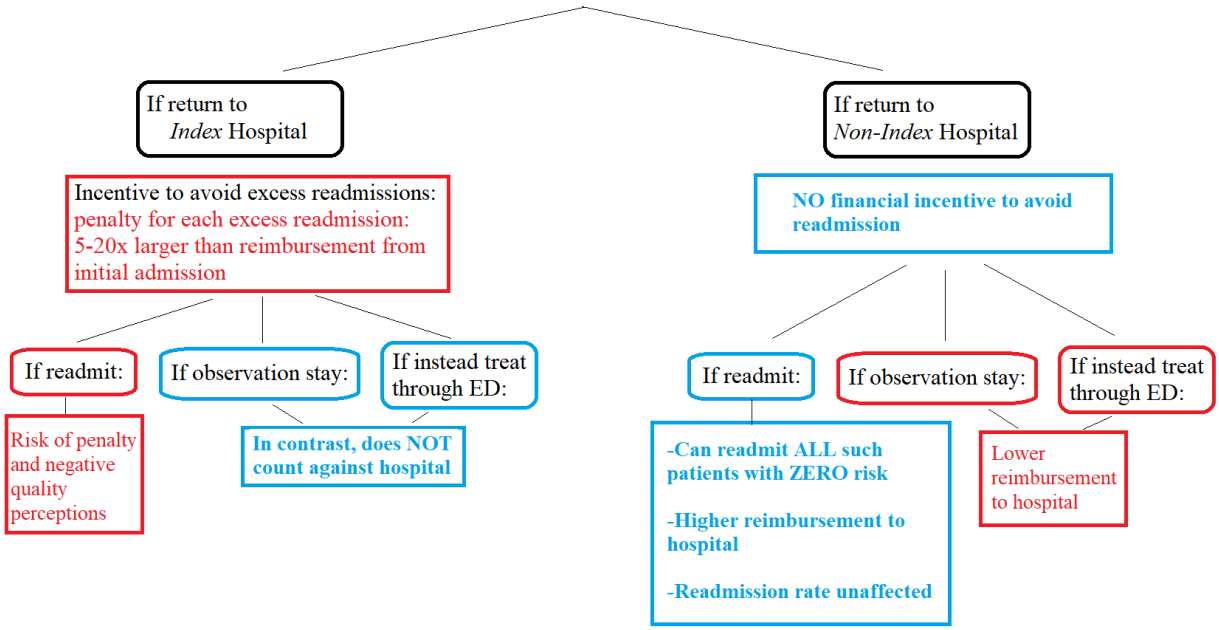

Figure 1.1: Asymmetric Financial Incentives

While *all non-index* hospitals (as defined relative to the given patient) have *zero* financial incentive to prevent such readmissions, among *index* hospitals, the magnitude of incentives for preventing such readmissions varies. Yet, because *non-index* readmission decisions are always attributed to the *index* hospital's statistics, there is always an important distinction between whether a hospital is an *index* or *non-index* hospital relative to the given patient. In particular, in contrast with *non-index* hospitals, *index* hospitals with zero financial marginal incentive may still face several key incentives for performance improvement.

This could occur in several ways, including hospital reputation under public reporting of HRRP measures, uncertainty about the general magnitude of their marginal incentive, and feeling responsible for patients initially admitted there while being primed to be more cautious about readmissions. First, hospitals may also be concerned about reputational effects, so they may still be incentivized to improve performance since it is publicly reported. Not only does strong performance on publicly reported measures present hospitals in a favorable light, but it can also raise bargaining power with insurers, improve the ability to attract and retain providers, and increase patient demand for their hospital services. It can also motivate and offer positive reinforcement for *index* hospital providers aiming to improve quality and reported performance while simultaneously forgoing direct reimbursement (from avoided readmissions).

Second, some hospitals may not have done the calculations to determine that they face zero financial marginal incentive for improvement on the given measure. This may be especially true for smaller or resource-constrained hospitals that may lack the analytic departments responsible for making such determinations to enhance profit.

Third, with a new underlying policy to incentivize reductions in readmissions among *index* hospitals, it may be easier for *index* hospitals to respond in a way that better serves patients (even at the expense of reimbursement). In contrast with *non-index* hospitals, *index* hospitals may feel more invested in patients who were initially admitted there. They may feel that those patients are their responsibility and they do not want to fail them under this policy of increased scrutiny of readmissions decisions. They may feel like it would look worse to fail patients who initially went there versus had gone somewhere else since they have more experience with and history of treating the given patient.

While *index* hospitals always face greater incentives for preventing the given readmissions (relative to *non-index* hospitals), those with larger financial incentives for improvement on a given readmission measure may improve even more. Among *index* hospitals, several factors can affect the magnitude of the given hospital's incentive to prevent AMI readmissions. These include the hospital-specific number of eligible discharges for each targeted condition, hospital performance on other readmission measures, and the hospital's Medicare percentage of inpatient days.

For a targeted condition's performance to be included in the adjustment ratio used to determine payment adjustment, the hospital must have (1) had at least 25 eligible discharges for the given condition, and (2) performed worse on the given measure than the expected readmission rate (i.e., the excess readmissions ratio [ERR] exceeds one). In the most recent performance period before the new stratified methodology took effect, 77.2 percent of HRRP-eligible hospitals had at least 25 discharges and an ERR above one for at least one measure and therefore received a financial penalty based on their performance. For the AMI measure, 27.2 percent of HRRP-eligible hospitals had fewer than 25 discharges and therefore that measure did not count towards their overall performance. Of the remaining hospitals, 42.1 percent performed as well as or better than expected on the measure, while 57.9 percent performed worse than expected on the measure.

This last group for each measure is included in the adjustment ratio used to determine payment adjustment for a given hospital. To the extent that a given hospital has fewer measures consequently included in its adjustment ratio, the more prominent the hospital's AMI readmissions performance is in determining its overall payment adjustment (if AMI readmissions is one of the hospital's included measures). Furthermore, because each condition-specific value

in the adjustment ratio used to determine payment adjustment reflects the product of (1) the condition-specific excess readmissions ratio (ERR) minus one and (2) the payment for the given condition, conditions with higher payments are weighted more heavily in the overall calculation. In addition, how well the hospital performs across each included measure can affect the hospital-specific incentive for preventing AMI readmissions. Because the overall payment adjustment is capped each year, hospitals whose payment adjustment would have exceeded the cap consequently face muted incentives to prevent readmissions than they would otherwise. Incentives to prevent readmissions among *index* hospitals also depend on the given hospital's Medicare percentage of inpatient days. The higher the hospital's Medicare percentage of inpatient days, the more reimbursement is at stake for the hospital due to changes in its performance.

To help curtail excessive readmissions to their hospital within 30 days, some *index* hospitals may also respond in ways that do not contribute towards their readmission statistics. This includes (1) using observation stays or care in emergency departments as a substitute or (2) delaying readmissions past the 30-day window. Care provided in the emergency department or through an observation stay is considered a potential alternative to a hospital admission. During the observation stay, providers evaluate the patient and deliver medically necessary services. Providers may later determine that the patient either can be discharged or requires additional treatment through a hospital admission (Wright, 2013; Harvard Pilgrim Health Care, 2020). Yet because the HRRP only penalizes hospitals for excessive readmissions rather than excessive emergency department care or observation stays, some *index* hospitals may instead provide care in emergency departments or use observation stays more prominently to reduce the risk or magnitude of penalization for certain readmission measures. Such hospitals may especially do so

for patients who (1) return to the *same* hospital within 30 days and (2) initially had an HRRP-targeted condition for which the hospital may anticipate a possible penalty.

This has financial implications for hospitals, patients, and Medicare. For hospitals, substituting towards observation stays means the hospital receives less direct revenue for the given visits, but, as noted, also reduced risk or magnitude of penalization due to excessive readmissions. For Medicare patients, receiving observation stays rather than readmissions can leave the patients with higher patient cost-sharing given Medicare coverage of such services (https://www.medicareresources.org/faqs/how-will-my-costs-be-affected-by-inpatient-or-observation-status/), and they may not qualify to receive Medicare-covered subsequent care in a skilled nursing facility. For Medicare, when hospitals use observation stays instead of readmissions, Medicare pays lower direct payments for the visits, but Medicare is not able to recoup related spending through the HRRP for cases that would otherwise have been excessive readmissions.

This research tests the hypotheses that hospitals' readmission, observation stay, and emergency department decisions for a given patient differentially changed for patients returning to *index* versus *non-index* hospitals, from before to after HRRP implementation, and that this effect increased with the hospital-specific marginal incentive for improvement. This research not only exploits variation in incentives between index and non-index hospitals from before to after HRRP implementation, but it also exploits variation in the magnitude of the hospital-specific marginal incentive.

Specifically, the underlying model includes terms capturing (1) whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation, for hospitals with zero financial marginal incentive for improvement under the

HRRP, but who are still subject to public reporting of performance, and (2) how the treatment effect changes with increases in the hospital-specific marginal incentive. The treatment effect refers to whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation. All analyses control for patient demographic and severity variables, hospital characteristics, as well as quarter-year and hospital fixed effects. Rigorous methods to account for patient selection of hospitals are also used, discussed in more detail in the methods section. After identifying all admissions for AMI, the main approach restricts to beneficiaries who return to *any* hospital within 30 days by ambulance, where hospital choice is effectively randomized by ambulances, using an instrumental variables approach. Moreover, this study only focuses on AMI, a targeted HRRP condition and an emergent condition for which hospital distance is critical.

1.3 Methods

1.3.1 Analytic Approach

This research investigates the HRRP's intended and unintended ramifications. First, this study calculates the hospital-specific marginal incentive (Norton et al., 2018; Norton, Lawton, Li, 2023) for improvement on the given readmissions measure for each hospital and time period. The hospital-specific marginal incentive for each condition measures how much an improvement in the condition-specific readmission would affect performance, and subsequently Medicare reimbursement. Because hospitals vary in their percentage of patients covered by Medicare, hospitals with greater dependence on Medicare revenue may be more responsive to financial incentives targeting the Medicare population. To account for this, the hospital-specific marginal

incentive to improve is subsequently scaled by the hospital's Medicare percentage of inpatient days in the given time period in all models.

Using national data, this study then investigates whether the probability of patients returning to *any* hospital within 30 days of an AMI HRRP initial admission (regardless of whether they were readmitted) changed as a function of the hospital-specific marginal incentive for improvement on the AMI measure following HRRP implementation. The hypothesis is that the coefficient sign will be negative, indicating that the probability of the given patient returning to *any* hospital within 30 days decreases as the original hospital's marginal incentive for improvement increases.

Subsequently, among patients who return to *any* hospital within 30 days, this research investigates whether the return hospitals' decisions to readmit the given patient differentially changed for patients returning to the same (index) hospital compared to patients returning to a different (non-index) hospital (as defined relative to the given patient), from before to after HRRP implementation, and that this effect increased with the hospital-specific marginal incentive for improvement.

In addition, this research tests how differing incentives for index and non-index hospitals affect patient outcomes, Medicare spending, and reported hospital quality measures, conditional on whether returning patients return to an index versus non-index hospital nationally. Because only *index* hospitals face financial incentives to reduce readmissions, the hospital-specific marginal incentive is captured separately for *index* and *non-index* hospital visits. This research conducts difference-in-differences analyses with adjustments for the magnitude of the hospital-specific marginal incentive. The difference-in-differences analyses control for time trends and compare changes in the key outcomes between the pre-HRRP and post-HRRP implementation

time periods. For all difference-in-differences analyses, this research first tests for parallel trends in the pre-period.

There are three sets of outcomes. The first reflects the probability of patients returning to *any* hospital within 30 days of an AMI HRRP initial admission (regardless of whether they were then readmitted). Second, there are three outcome measures that reflect potential hospital responses to the given patient who returned to *any* hospital within 30 days. They include the probability of a readmission, an observation stay, and care given in the emergency department, respectively, conditional on returning to *any* hospital within 30 days. Third, there are four outcome measures that reflect subsequent patient outcomes, Medicare spending, and reported hospital quality measures. They include the following two measures: (1) probability of mortality within 60 days following the hospital revisit (regardless of whether they were readmitted) and (2) total spending on the hospital revisit (regardless of whether they were readmitted). For reported hospital measures, the main outcome measures include changes in (1) hospitals' measure-specific performance and (2) overall HRRP performance as a result of the change in their readmission rate due to a change in AMI readmissions from beneficiaries who return to *any* hospital within 30 days being treated like beneficiaries returning to the *index* hospital.

For each outcome of interest Y, this research estimates the differential change in the outcome for patients returning to index versus non-index hospitals (as defined relative to the given patient), from before to after HRRP implementation, with adjustments for the magnitude of the hospital-specific marginal incentive for improvement. There are two key explanatory measures of interest. The first reflects whether there is a difference between index and non-index hospitals after HRRP implementation, for hospitals with zero financial marginal incentive for improvement under the HRRP, but who are still subject to public reporting of performance. This

reflects a difference-in-differences model. The second reflects whether the treatment effect increases with the hospital-specific marginal incentive. This is a difference-in-difference-in-differences model. The treatment effect refers to whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation.

Additionally, all analyses control for patient demographic and severity variables, hospital characteristics, as well as quarter-year and hospital fixed effects. For all analyses, cluster-robust standard errors are estimated to account for repeated observations within hospitals.

The following reflects the main regression model at the patient level for patient *i*, hospital *j*, and time-period *t* for patients returning to *any* hospital within 30 days of the given AMI admission (Equation 3).

$$
\begin{aligned}
(3)\ Y_{i,j,t} = {} & \beta_0 + \beta_1 IndexHospital_{i,t} + \beta_2 Post_t \\
& + \beta_3 IndexHospital_{i,t} \times Post_t && \text{[Difference-in-Differences]} \\
& + \beta_4 HospMarginalIncentive_{j,t} \\
& + \beta_5 HospMarginalIncentive_{j,t} \times IndexHospital_{i,t} \\
& + \beta_6 HospMarginalIncentive_{j,t} \times Post_t \\
& + \beta_7 IndexHospital_{i,t} \times Post_t \times HospMarginalIncentive_{j,t} && \text{[Difference-in-Difference-in-Differences]} \\
& + \beta_8 X_{i,t} + \beta_9 H_j + \beta_{10}(Quarter \times Year_t) + \beta_{11}\lambda_j + \varepsilon_{i,j,t} && \text{[Additional Controls]}
\end{aligned}
$$

where $IndexHospital_{i,t}$ reflects whether the hospital to which the patient returned was the index hospital (or, in sensitivity analyses, a hospital within the same hospital system as the index hospital), $Post_t$ is whether the time period was after HRRP implementation, $HospMarginalIncentive_{j,t}$ is the hospital-specific marginal incentive for improvement on the AMI

readmissions measure, $Quarter \times Year_t$ is the time period that the visit occurred, $X_{i,t}$ is a vector of patient characteristics (age, gender, race, dual eligibility, severity (based on Hierarchical Condition Category and Elixhauser Comorbidity Index approaches)), H_j is a vector of hospital characteristics (such as size and Disproportionate Share Hospital (DSH) percent), λ_j reflects hospital fixed effects, and $\varepsilon_{i,j,t}$ is an error term.

The first coefficient of interest is the coefficient on the index hospital and post-period interaction term (β_3), which captures whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation, for hospitals with zero financial marginal incentive for improvement under the HRRP, but who are still subject to public reporting of performance. The second coefficient of interest is the coefficient on the triple interaction between index hospital, post-period, and hospital-specific marginal incentive term (β_7), which captures how the treatment effect changes with increases in the hospital-specific marginal incentive. The treatment effect refers to whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation.

For the readmission models, the hypothesis is that the treatment effect will be negative because, unlike non-index hospitals, index hospitals are subject to performance incentives following HRRP implementation to reduce reported readmissions. In contrast, because the hospitals that face these performance incentives may be more likely to shift returning patients to observation or ED care status following HRRP implementation, the hypothesis is that the treatment effect will be positive for the observation stay and ED care models. Because *index* hospitals may face pressure to avoid readmitting returning patients who would benefit from readmission, the hypothesis is that the treatment effect may be positive for the probability of mortality models.

Because total spending on the revisit to the hospital depends on the hospital's emergency department care, observation stay, and readmission decisions as well as the intensity of care delivered, a decrease in spending would be expected for index hospitals as they pursue less expensive and extensive care such as fewer readmissions. Consequently, for the total spending on the revisit to the hospital models, the hypothesis is that the treatment effect will be negative.

Table 1.1: Study Population, Outcomes, and Hypothesized Sign of Treatment Effect

Study Population	Main Outcome	Hypothesized Sign
Study Population 1	*Probability of Return to Any Hospital:*	
	Return to *Any* Hospital Within 30 Days (Regardless of Mode of Transportation or Readmission)	–
Study Population 2	*Probability of Hospital Care Decision:*	
	Readmission	–
	Observation Stay	+
	Emergency Department Care	+
	Probability of Mortality Post-Hospital Revisit:	
	Mortality Within 60 Days of Revisit to *Any* Hospital (Regardless of Readmission)	+
	Mean Medicare Facility Spending:	
	Spending on Revisit to *Any* Hospital Within 30 Days (Regardless of Readmission)	–

Notes: There are two study populations which focus on the AMI population targeted by the HRRP. Study Population 1 reflects all Medicare beneficiaries (1) older than 65, (2) discharged in 2009-2017 from an HRRP AMI index admission at a hospital that consistently met the minimum case requirements to receive an HRRP AMI measure score, (3) who were continuously enrolled in Part A and Part B of FFS Medicare for the full 12 months leading up to the index admission and enrolled in Part A during the index admission, (4) were not transferred to another acute care facility, and (5) were alive at discharge. For the analyses conditional on returning to any hospital, the above study population was restricted to a second study population. Specifically, Study Population 2 reflects patients who had a revisit to any hospital (that consistently met the minimum case requirements to receive an HRRP measure score) within 30 days by ambulance (regardless of whether they were readmitted).

Table 1.1 provides an overview of each main outcome and the hypothesized treatment effect sign. It is also hypothesized that the treatment effect will be stronger as the hospital-specific marginal incentive increases.

Additionally, this research evaluates how differing incentives for *index* and *non-index* hospital visits could affect reported hospital performance. It calculates the change in the reported hospital quality measure of interest due to a change in readmissions from patients being treated like patients returning to an index hospital. Specifically, after estimating the previous probability of readmission model, this research calculates two sets of predicted probabilities by hospital urban status and whether the index hospital had an average non-zero scaled marginal incentive over the study time frame. First, it calculates the average predicted probability of readmission, as if *all* of a given hospital's patients who return to any hospital within 30 days returned to the *index* hospital post-HRRP implementation (regardless of whether they were readmitted). This entails calculating adjusted predicted probability of readmission values for all observations as if the index hospital and post-HRRP implementation values are one for all such patients, while maintaining other variables as is, and then calculating the average adjusted predicted probability of readmission value. Second, it calculates the average predicted probability of readmission, using the average percentage of patients who return to the *index* hospital post-HRRP implementation for all of a given hospital's patients who return to *any* hospital within 30 days (regardless of whether they were readmitted). This entails calculating adjusted predicted probability of readmission values for all such observations as if the index hospital value is equal to the average for the given hospital group and the post-HRRP implementation value is one, while maintaining other variables as is, and then calculating the average adjusted predicted

probability of readmission value. Then, the difference in these average predicted probabilities of readmission values is calculated.

For each *specific* urban index hospital with an average non-zero scaled marginal incentive over the study time frame, this research then estimates how a change of this magnitude in the numerator of the ERR would change the hospital-specific ERR, the overall hospital-specific adjustment ratio, and hospital-specific penalties. This sheds light on how reported hospital performance is affected due to differing incentives for index and non-index hospitals leading to a change of this magnitude.

In addition, after identifying all admissions for AMI, this research accounts for patient selection of hospitals. For example, patients may choose hospitals because of the given hospital's perceived quality or capabilities. This means that high quality hospitals may end up treating the most complex or sickest cases in the geographic area. On the other hand, patients who choose hospitals perceived to be higher quality may be more savvy consumers of health information and in better health. It is necessary to address patient selection of hospitals to avoid selection bias. The main method of addressing patient selection uses an instrumental-variables approach that builds on the work of Doyle and colleagues (Doyle et al., 2015; Doyle, Graves, Gruber, 2019). It identifies beneficiaries who return to *any* hospital within 30 days by ambulance and restricts analysis to just them. Whereas including all beneficiaries regardless of residence location and travel method to the hospital could introduce situations where patients' hospital choice is not random, restricting to beneficiaries brought by ambulance removes this selection. Specifically, as discussed in the Doyle et al. paper, the ambulance company dispatched to the given patient is effectively random because of rotational assignment or even direct competition between simultaneously dispatched companies. Additionally, ambulance companies that serve the same

area have preferences regarding which hospital they transport patients. Consequently, the choice of hospital is not based on quality but instead is effectively random based on the ambulance company and distance to the nearest hospital. The instrument for whether the given patient returned to the index hospital or a non-index hospital is the percent brought to the hospital the given patient visited for the initial admission (the given *index* hospital). The instrument denominator is all other patients picked up by the same ambulance company. Furthermore, there are several additional instruments. This is because the endogenous variable, which reflects whether the given patient returns to the index or a non-index hospital, is interacted with other variables in the model. As a result, there is also one corresponding instrument for each endogenous interaction term. Moreover, all analyses focus on the AMI HRRP measure because AMI reflects an emergent condition for which hospital distance is critical.

Together, these approaches provide specifications to account for patient selection of hospitals and avoid instances of endogenous hospital choice. These approaches are preferable to other approaches, such as using differential distance as an instrumental variable, which may not fully account for hospital selection based on quality. If differential distance as an instrumental variable were used instead, there could be remaining concerns about areas with numerous nearby hospitals, where it is possible that choice could still be endogenous. In contrast, the proposed methods address that source of selection bias, and because the HRRP is a mandatory program, this eliminates selection bias that would exist among hospitals opting to participate in voluntary programs.

1.3.2 Data Sources and Study Population

To investigate whether hospitals' decisions to readmit a given patient differentially changed for index hospitals compared to non-index hospitals following HRRP implementation, as well as to evaluate how differing incentives for index and non-index hospitals affect patient outcomes, Medicare spending, and reported hospital quality measures, this research needs national data on hospital visits for Medicare beneficiaries before and after HRRP implementation. This research also needs information on provider readmission, observation stay, and emergency department decisions; patient demographics; patient severity; mortality; whether a given patient was brought to the hospital by ambulance; timing and location of visits and stays; as well as Medicare spending. Additionally, for every hospital, this research needs data on hospital characteristics, HRRP performance, and previous payment adjustments resulting from the HRRP to control for these factors in the analyses.

This research uses claims data over years 2008 to 2018 from the Medicare Provider Analysis and Review, Outpatient, and Carrier Research Files for a national random 20% sample of Medicare beneficiaries. This enables me to identify hospital visits; whether a given hospital reflects an index or non-index hospital; readmission, observation stay, and emergency department decisions; patient demographics; patient severity; mortality; whether a given patient was brought to the hospital by ambulance; the time period and location of the visit or stay; and spending for the given services. Additionally, this research merges these data with the Master Beneficiary Summary File to obtain additional beneficiary characteristics. To control for hospital characteristics such as number of beds, Medicare share of inpatient days, and Disproportionate Share Hospital (DSH) percent, this research supplements the data with the Impact File, the Provider of Services File, and the American Hospital Association Annual Survey. To

additionally incorporate hospital-specific incentives, this research uses lagged HRRP performance data for each hospital and time frame from the main and supplemental HRRP data files.

This study focuses on AMI patients because AMI reflects a targeted condition under the HRRP; an emergent condition for which hospital distance is critical; a common, costly condition; as well as a condition responsible for frequent readmissions, including a considerable number to non-index hospitals.

Among AMI patients, there are two study populations which focus on the population targeted by the HRRP. Specifically, this research identities all Medicare beneficiaries (1) older than 65, (2) discharged in 2009-2017 from an *HRRP AMI initial admission* at a hospital that consistently met the minimum case requirements of at least 25 discharges to receive an HRRP AMI measure score, (3) who were continuously enrolled in Part A and Part B of FFS Medicare for the full 12 months leading up to the initial admission and enrolled in Part A during the initial admission, (4) were not transferred to another acute care facility, and (5) were alive at discharge. This incorporates criteria for beneficiaries admitted for an AMI to be included under the HRRP. Together, the above criteria comprise the *first study population*, which is used in the probability of a revisit to *any* hospital (regardless of readmission) within 30 days analysis.

Additionally, for the analyses *conditional on returning to any hospital*, the above study population was restricted to a *second study population*. Specifically, the second study population reflects patients who had a revisit to *any* hospital (that consistently met the minimum case requirements of at least 25 discharges to receive an HRRP measure score) within 30 days by ambulance (regardless of whether they were readmitted).

1.4 Results

1.4.1 Variation in the Scaled Marginal Incentive for Hospitals to Reduce AMI Readmissions

While *non-index* hospitals always lack *any* financial incentives to curtail readmissions, the scaled marginal incentive to improve on the HRRP AMI measure varies across *index* hospitals. Figure 1.2 focuses on the scaled marginal incentive for revisits to the original (*index*) hospital in post-penalty fiscal years. Specifically, it shows the variation in the hospital-specific scaled marginal incentive, among revisits by ambulance to the original hospital within 30 days of a FY 2012-2017 discharge from an AMI HRRP admission. A considerable percentage of such revisits had zero or a very small marginal incentive at the time of the revisit. In particular, a one-decile improvement in their reported AMI measure performance would not increase or would barely increase the percentage of base operating diagnosis-related group (DRG) payments these hospitals would receive in the given time frame.

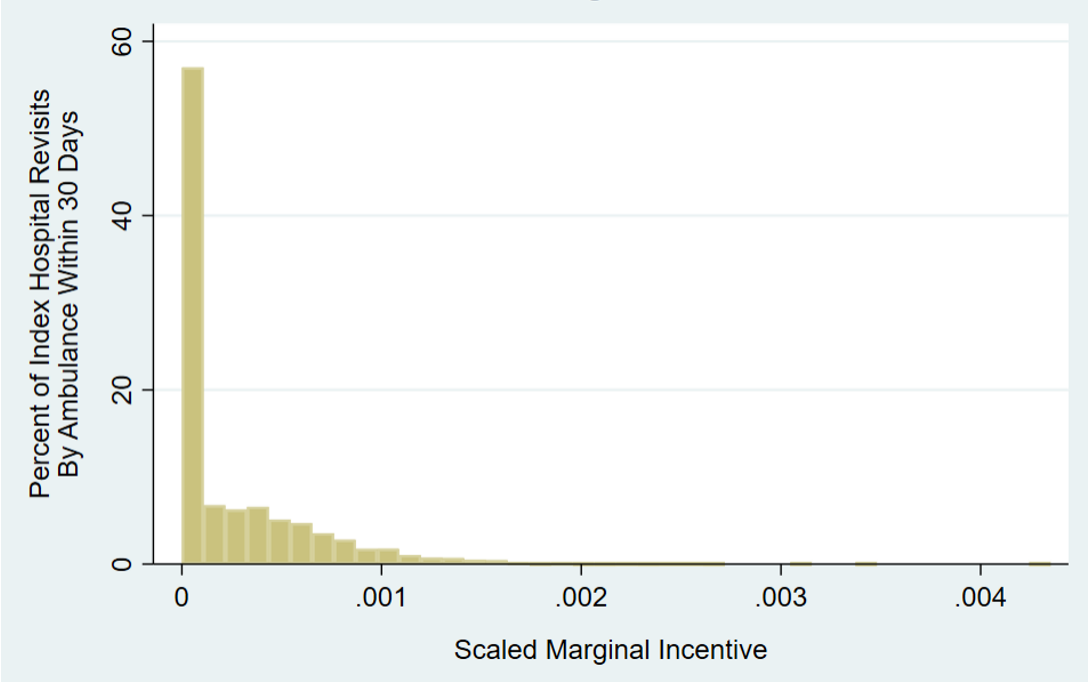

Figure 1.2: Histogram of Scaled Marginal Incentive

Figure 1.3 shows the variation in the scaled marginal incentive for improvement on the HRRP AMI measure, *among the Figure 1.2 revisits with a positive marginal incentive for improvement*. Among such revisits, the average scaled marginal incentive was 0.0005.

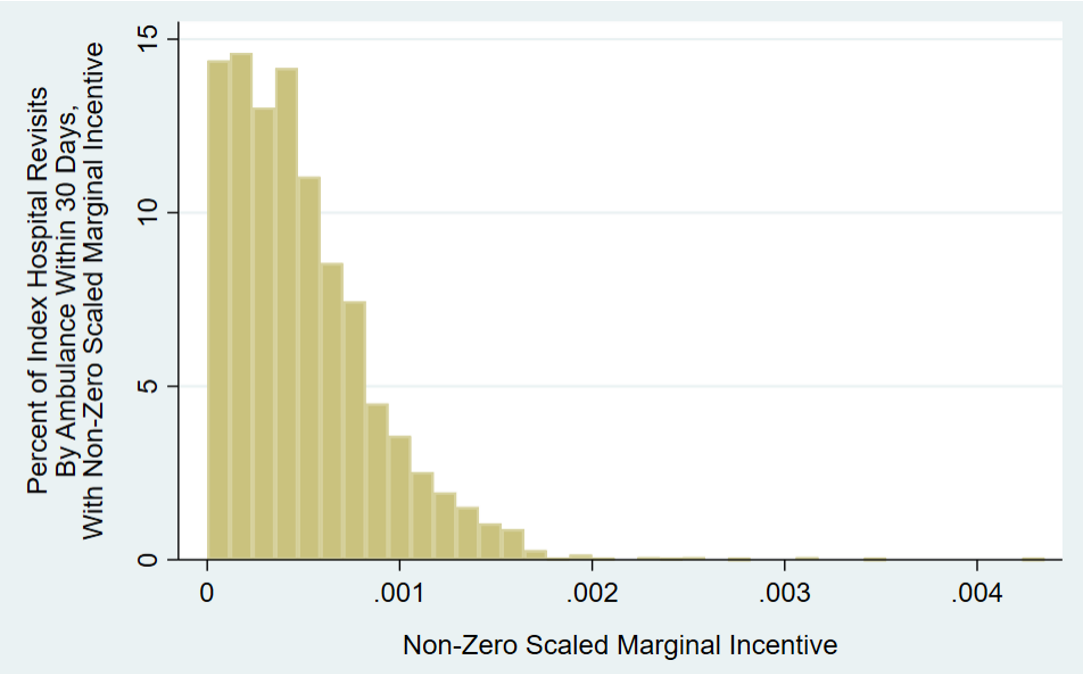

Figure 1.3: Histogram of Non-Zero Scaled Marginal Incentive

1.4.2 Beneficiary and Hospital Characteristics of Beneficiaries Returning to Any Hospital by Ambulance Within 30 Days

As noted above, for the probability of a revisit within 30 days analysis, the *first study population* reflects beneficiaries discharged in 2009-2017 from an HRRP AMI initial admission regardless of whether they subsequently returned to *any* hospital (for the full description of the *two study populations*, see the above Study Population section). This produced a national sample of 248,066 beneficiaries.

As noted above, for the analyses *conditional on returning to any hospital*, a *second study population* was formed by restricting the first study population to beneficiaries who returned to *any* hospital. Specifically, the second study population reflects patients who had a revisit to *any* hospital (that consistently met the minimum case requirements of at least 25 discharges to receive an HRRP measure score) within 30 days by ambulance (regardless of whether they were readmitted). This produced a national sample of 24,823 beneficiaries. Table 1.2 presents descriptive statistics of outcome variables for this *second study population* over the full study time frame across hospitals.

Table 1.2: Descriptive Statistics Over Study Time Frame, Key Outcome Variables, Beneficiaries Discharged in 2009-2017 From an HRRP AMI Index Admission Who Then Had Revisit to a Hospital Within 30 Days by Ambulance (Regardless of Whether Readmitted)

Care Decisions, Conditional on Returning to Any Hospital by Ambulance Within 30 Days (Regardless of Readmission), Over Full Time Period		***n***	***%***
***Non-Mutually Exclusive* Care Decisions**	**Any ED Visit Care (Regardless of Observation Stay or Readmission Status)**	**20,117**	**81.0**
	Any Observation Stay (Regardless of ED Visit Care or Readmission Status)	**3,096**	**12.5**
	A*ny* Readmission (Regardless of ED Visit Care or Observation Stay)	**16,427**	**66.2**
***Mutually Exclusive* Care Decisions**	**Emergency Department Care Or Observation Stay, But No Readmission**	**8,396**	**33.8**
	Emergency Department Care Or Observation Stay, And Readmission	**11,824**	**47.6**
	Readmission But No Emergency Department Care Nor Observation Stay	**4,603**	**18.5**
Mortality Post-Hospital Revisit		**n**	**%**
Mortality Within 60 Days of Revisit to *Any* Hospital (Regardless of Readmission)		**2,727**	**11.0**
Medicare Facility Spending		***Mean***	
Spending on Revisit to *Any* Hospital Within 30 Days (Regardless of Readmission)		**$7,721**	

Notes: This table presents descriptive statistics for the study population that returned to *any* hospital within 30 days by ambulance (n=24,823).

Table 1.3: Key Patient and Hospital Characteristics Over Study Time Frame, Beneficiaries Discharged in 2009-2017 From an HRRP AMI Index Admission Who Then Had Revisit to a Hospital Within 30 Days by Ambulance (Regardless of Whether Readmitted)

Key Patient Characteristics, Over Full Time Period	***n***	***%***
Gender		
Female	13,506	54.4
Male	11,317	45.6
Race		
White	21,434	86.4
Black	2,217	8.9
Hispanic	490	2.0
Other	682	2.8
Dually Eligible in Original Hospital Discharge Month		
Not dually eligible	19,613	79.0
Dually eligible	5,210	21.0
Any ICU Days During Original Admission		
No ICU Days	11,821	47.6
Any ICU Days	13,002	52.4
Mean HCC Community Score	3.3	
Median Index Hospital Length of Stay (in Days)	4.0	
Mean Age at End of Reference Year	80.5	
Key Characteristics of Most Recent Hospital	***n***	***%***
Hospital Size		
<100 Beds	1,199	4.8
100-299 Beds	11,535	46.5
300+ Beds	12,089	48.7
Teaching Affiliation	14,348	57.8
For-Profit Hospital	3,638	14.7
Safety-Net Hospital	7,857	31.7
Received Penalty Based on:		
AMI Performance in Prior Year, in Penalty Period	5,740	50.3
Performance on Any of the Measures in Prior Year, in Penalty Period	9,202	80.6
AMI Performance in Prior Year, in Penalty Period, Conditional on Receiving a Penalty on Any of the Measures in Prior Year	5,740	62.4
	Mean	
Disproportionate Share Hospital (DSH) Percent	26.5	
Prior FY Payment Adjustment Factor, in Penalty Period	0.996	
Prior FY AMI Excess Readmissions Ratio Minus 1, in Penalty Period	0.035	
Medicare Percentage of Inpatient Days	43.7	

Notes: This table presents key patient and hospital characteristics for the study population that returned to *any* hospital within 30 days by ambulance (n=24,823).

Table 1.4: Key Patient and Hospital Characteristics Over Study Time Frame, by Index and Non-Index Hospital Status, Beneficiaries Discharged in 2009-2017 From an HRRP AMI Index Admission Who Then Had Revisit to a Hospital Within 30 Days by Ambulance (Regardless of Whether Readmitted)

Key Patient Characteristics, Over Full Time Period	*Index Hospitals*		*Non-Index Hospitals*	
	n	***%***	***n***	***%***
Gender				
Female	10,649	55.1	2,857	51.9
Male	8,666	44.9	2,651	48.1
Race				
White	16,754	86.7	4,680	85.0
Black	1,701	8.8	516	9.4
Hispanic	347	1.8	143	2.6
Other	513	2.7	169	3.1
Dually Eligible in Original Hospital Discharge Month				
Not dually eligible	15,300	79.2	4,313	78.3
Dually eligible	4,015	20.8	1,195	21.7
Any ICU Days During Original Admission				
No ICU Days	9,226	47.8	2,595	47.1
Any ICU Days	10,089	52.2	2,913	52.9
Mean HCC Community Score	3.3		3.3	
Median Index Hospital Length of Stay (in Days)	4.0		4.0	
Mean Age at End of Reference Year	80.8		79.3	
Key Characteristics of Most Recent Hospital	***n***	***%***	***n***	***%***
Hospital Size				
<100 Beds	715	3.7	484	8.8
100-299 Beds	8,771	45.4	2,764	50.2
300+ Beds	9,829	50.9	2,260	41.0
Teaching Affiliation	11,439	59.2	2,909	52.8
For-Profit Hospital	2,786	14.4	852	15.5
Safety-Net Hospital	6,002	31.1	1,855	33.7
	Mean		***Mean***	
Disproportionate Share Hospital (DSH) Percent	26.3		27.2	
Medicare Percentage of Inpatient Days	43.6		43.9	

Notes: This table presents key patient and hospital characteristics for the study population that returned to *any* hospital within 30 days by ambulance (n=24,823).

Table 1.3 presents patient characteristics of this *second study population* as well as hospital characteristics for the hospitals to which these patients returned within 30 days by ambulance. Table 1.4 presents such characteristics by index and non-index hospital status. As shown, patient and hospital characteristics are overall very similar for index and non-index hospitals for this study population, especially measures of patient severity. This makes sense given that this population reflects patients who returned to a hospital by ambulance, where patient choice is effectively randomized by ambulances. Moreover, changes in characteristics over time are consistent across index and non-index hospitals. Additionally, subsequent models include hospital and quarter-year fixed effects.

1.4.3 Preliminary Analyses

As anticipated, the parallel trends in the pre-period assumption was satisfied. There was *no* statistically significant change in the trends of outcomes in the *pre*-HRRP implementation quarter-years between whether a given patient returned to an *index* hospital versus a *non-index* hospital. In contrast, comparing the start of the study period to *post*-HRRP implementation quarter-years, there *was* a statistically significant change in the trend of outcomes between whether patients returned to an *index* hospital versus a *non-index* hospital.

Moreover, over the full study time frame, there was *no* statistically significant difference — overall or by patient severity — in whether a given patient returned to an *index* hospital versus a *non-index* hospital (conditional on the given patient returning to *any* hospital within 30 days by ambulance).

1.4.4 Effects of the HRRP on the Probability of a Revisit to Any Hospital Within 30 Days

Over the full study period, 29.5 percent of study population 1 returned to *any* hospital within 30 days overall (regardless of mode of transportation or readmission). For the first study population, Table 1.5 presents the probability of returning to *any* hospital within 30 days (regardless of mode of transportation or readmission) results. It shows that the probability of the given patient returning to *any* hospital within 30 days decreased by 0.3 percentage points, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure.

Table 1.5: Probability of Revisit to Any Hospital Within 30 Days Results (Regardless of Readmission)

Outcome Measure, *For Full HRRP AMI Study Population*	Coefficient (Multiplied by 0.0005 Average Scaled Marginal Incentive)	
Return to *Any* Hospital Within 30 Days (Regardless of Readmission)	-0.3 (0.2)	*

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 0.0005 average non-zero scaled marginal incentive) from the probability of revisit to *any* hospital within 30 days results. This reflects the change in the *percentage points of probability* of returning to *any* hospital within 30 days, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure (due to a one-decile change in the AMI Excess Readmissions Ratio). The study population for these analyses reflects beneficiaries with a 2009-2017 discharge from an AMI HRRP index admission.

As providers face larger incentives to improve on the HRRP AMI measure, the probability of their patients returning to any hospital decreases. This is consistent with the conceptual framework and the study hypotheses for provider responsiveness to the underlying HRRP incentive design. The results show that as the financial incentives for visits increase, index hospitals may be investing additional effort in preventing patients from receiving additional hospital care within 30 days, such as pursuing improved discharge procedures.

1.4.5 Effects of the HRRP on Hospital Readmission Decisions, Conditional on a Revisit to Any Hospital Within 30 Days

Exploiting exogenous variation in hospital incentives — variation in treatment of index versus non-index hospital visits from before to after the HRRP, along with variation in the magnitude of the hospital-specific scaled marginal incentive — this research obtains causal estimates of the effects of the HRRP on patients, Medicare, and hospitals nationally. Among study population 1 beneficiaries, 24,823 returned to *any* hospital by ambulance within 30 days following discharge from an AMI HRRP initial admission. Because the HRRP applies penalties for excessive 30-day readmissions, but not emergency department care or observation stays, there is a stronger incentive for index hospitals to treat beneficiaries returning to the hospital within 30 days just through emergency department care or an observation stay rather than a readmission. Furthermore, this effect is likely to be greater as the hospital-specific scaled marginal incentive for improvement in the AMI HRRP measure increases.

Table 1.6 presents the instrumental variable results of the differential change in the percentage points of probability of the given outcome measure, with increases in the scaled

marginal incentive for index hospital visits compared to non-index hospital visits, post-HRRP implementation.

Table 1.6: Instrumental Variables Results: Emergency Department Care, Observation Stay, and Readmission Decisions, as well as Patient Mortality

Whether Mutually Exclusive Care Decision	Outcome Measure, *For HRRP AMI Study Population That Returned to Any Hospital Within 30 Days by Ambulance* (Regardless of Whether Readmitted)	Coefficient (Multiplied by 0.0005 Average Scaled Marginal Incentive)	
Non-Mutually Exclusive Care Decisions	*Any* Emergency Department Care (Regardless of Readmission or Observation Stay)	4.2	**
	Any Observation Stay (Regardless of Readmission or Emergency Department Care)	3.4	
	Any Readmission (Regardless of Emergency Department Care or Observation Stay)	-6.8	*
Mutually Exclusive Care Decisions	Emergency Department Care Or Observation Stay, But *No* Readmission	6.8	*
	Emergency Department Care Or Observation Stay, *And* Readmission	-2.7	
	Readmission, But *No* Emergency Department Care *Nor* Observation Stay	-4.1	**
	Mortality Within 60 Days of Date of Hospital Revisit	0.9	

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 0.0005 average non-zero scaled marginal incentive) from the instrumental variable results of the differential change in percentage points of probability of the outcome variable, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. The first panel reflects *non-mutually exclusive* care decisions by the hospital to which the given beneficiary returned, conditional on the AMI HRRP beneficiary returning to *any* hospital within 30 days (regardless of readmission). The second panel reflects mutually exclusive care decisions by the hospital to which the given beneficiary returned, conditional on the AMI HRRP beneficiary returning to any hospital within 30 days (regardless of readmission). The study population for each of these analyses reflects the AMI HRRP beneficiaries who return to *any* hospital (regardless of readmission) by ambulance within 30 days of a 2009-2017 discharge from an AMI HRRP index admission.

The first set of results presents *non-mutually exclusive* care decisions, conditional on returning to *any* hospital within 30 days by ambulance. The second set of results presents *mutually exclusive* care decisions, conditional on returning to *any* hospital within 30 days by ambulance. The third set of results presents mortality within 60 days of the revisit results.

For the *non-mutually exclusive* care decisions (top panel of Table 1.6), indeed, there was a differential increase in the probability of treating the given patient through emergency department care (regardless of readmission or observation stay), with increases in the hospital-specific scaled marginal incentive for improvement on the hospital's reported HRRP AMI Measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. Specifically, for each increase of 0.0005 scaled marginal incentive (corresponding to the average scaled marginal incentive value among positive scaled marginal incentive values), the probability of being treated in the emergency department (regardless of readmission or observation stay) increased by 4.2 percentage points ($p<0.05$). In contrast, the differential change in the probability of treating patients through an observation stay (regardless of readmission or emergency department care) did not increase significantly with increases in the hospital-specific scaled marginal incentive ($p=0.317$).

From before to after HRRP implementation, there was a differential decrease in the probability of a readmission (regardless of emergency department care or observation stay), with increases in the hospital-specific scaled marginal incentive for improvement on the hospital's reported HRRP AMI Measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. In particular, for each increase of 0.0005 scaled marginal incentive, the

probability of a readmission (regardless of emergency department care or observation stay) decreased by 6.8 percentage points (p<0.10). The second panel in Table 1.6 decomposes these *non-mutually exclusive* care decisions into *mutually exclusive* care decisions. The results reveal a significant shift from readmitting the given patient to instead treating the given patient through emergency department care, for index hospital visits compared to non-index hospitals post-HRRP implementation, and that the differential change increased with increases in the hospital-specific scaled marginal incentive. Specifically, there was a differential *increase* in the probability of treating the given patient through *emergency department care or an observation stay instead of a readmission*, with increases in the hospital-specific scaled marginal incentive for improvement on the hospital's reported HRRP AMI Measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. For each increase of 0.0005 scaled marginal incentive, the probability of treating the given patient through *emergency department care or observation stay instead of a readmission increased* by 6.8 percentage points (p<0.10).

Moreover, from before to after HRRP implementation, there was a differential *decrease* in the probability of *readmission rather than emergency department care or observation stay*, with increases in the hospital-specific scaled marginal incentive for improvement on the hospital's reported HRRP AMI Measure, for index hospital visits compared to non-index hospital visits, post-HRRP implementation. In particular, for each increase of 0.0005 scaled marginal incentive, the probability of *readmission rather than emergency department care or observation stay decreased* by 4.1 percentage points (p<0.05). The differential change in the probability of treating the given patient with *emergency department care or observation stay, as well as a readmission* (-2.7 percentage points) was not statistically significant. Together, these

results are consistent with the Conceptual Framework and the study hypotheses for provider responsiveness to the underlying HRRP incentive design. They show that providers change their care decisions as the financial incentives for a given visit increase. In response, they shift from readmitting the given patient to treating the given patient through emergency department care.

1.4.6 Effects of the HRRP on Hospital Facility Revisit Spending

From before to after HRRP implementation, there was a differential decrease in Medicare facility spending for the revisit (regardless of readmission) of $2,110 per patient, for index hospital visits compared to non-index hospital visits, with increases in the hospital-specific scaled marginal incentive for improvement on the hospital's reported HRRP AMI Measure (due to a one-decile change in the AMI Excess Readmissions Ratio) post-HRRP implementation (Table 1.7).

Table 1.7: Instrumental Variables Results: Medicare Facility Spending

Outcome Measure, *For HRRP AMI Study Population That Returns to Any Hospital Within 30 Days by Ambulance* (Regardless of Whether Readmitted)	Coefficient (Multiplied by 0.0005 Average Scaled Marginal Incentive)	
Revisit Spending (Regardless of Readmission)	-2,110	**

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 0.0005 average non-zero scaled marginal incentive) from the instrumental variable results of the differential change in Medicare facility spending, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. The study population for these analyses reflects the AMI HRRP beneficiaries who return to *any* hospital (regardless of readmission) by ambulance within 30 days of a 2009-2017 discharge from an AMI HRRP index admission.

1.4.7 Effects of the HRRP on Reported Hospital Performance

Table 1.8 shows the effect of differing incentives for *index* hospital visits versus *non-index* hospital visits on average reported hospital quality measures over FY 2015-2017 (the study time frame corresponding to the final maximum allowable percentage penalty of three percent). As noted above, under the HRRP, readmission decisions at *non-index* hospitals are *always* attributed *only* to the *index* hospital. Furthermore, as previously noted, there was a differential decrease in the probability of a readmission, with increases in the hospital-specific scaled marginal incentive, for *index* hospital visits compared to *non-index* hospital visits, post-HRRP implementation. Consequently, a given hospital's reported hospital performance is *negatively affected simply* by patients returning to other hospitals rather than the original hospital.

Specifically, for the urban hospitals where beneficiaries in the study population were initially admitted that had an average non-zero scaled marginal incentive over the study time frame, the reported hospital HRRP AMI measure would *decrease* (lower values reflect better performance) by an average of 0.03038 *simply by patients instead returning to the original hospital, which faces incentives to curtail readmissions, rather than a non-index hospital, which lacks incentives to curtail readmissions*. In other words, this reflects the AMI readmissions measure decrease that would result from a greater percentage of patients returning to the index hospital and being subjected to its lower probability of readmission, given that it is subject to financial incentives to curtail readmissions.

Because any AMI ERR value above one is included in the penalty formula, lower ERR values are better and decrease the probability and magnitude of hospital penalization. This translates into an average decrease in the percent penalty of 0.00044 *simply by patients instead returning to the original hospital*. With sizable spending at stake, even small percentage

reductions to the base payment amount due to penalties can reflect meaningful losses in reimbursement. Moreover, this reflects results for only the AMI population, indicating that the effects on reported hospital performance measures are even larger if all HRRP conditions/procedures are considered.

Table 1.8: Change in Reported Hospital Performance Solely Due to Change in AMI Readmissions from Study Population 2 Beneficiaries Being Treated Like Study Population 2 Beneficiaries Returning to an Index Hospital

Reported Performance Measure	***Average Difference***
Decrease in Reported AMI Excess Readmissions Ratio	-0.03038
Decrease in Penalty Percentage	-0.00044

1.5 Discussion

This research has numerous implications that arise from the empirical findings. First, it shows that hospitals are responsive to financial incentives underlying the specific design of the HRRP. This has beneficial implications in that the premise of pay-for-performance programs is that financial incentives can be employed to improve care delivery and quality. Consequently, using financial incentives to shape care decisions to reduce readmissions can work under key conditions. In contrast, this has negative implications in that the HRRP has unintended consequences and muted overall effects in light of its specific incentive design. Yet this provides opportunities for policy refinement to further target financial incentives to improve patient, hospital, and Medicare outcomes in light of research findings.

Second, this research shows that original admitting hospitals respond to the financial incentives by decreasing the probability of the given patient returning to *any* hospital within 30 days, *as the hospital-specific scaled marginal incentive increases*. The intensive margin matters. Furthermore, for AMI beneficiaries returning to a hospital within 30 days, hospitals respond by differentially increasing emergency department care as well as reducing readmissions for *index* hospital visits (compared to *non-index* hospital visits) post-HRRP implementation as the *index* hospital-specific scaled marginal incentive to improve on the AMI HRRP measure increases. Additionally, there was evidence to suggest that the particular day around the 30-day threshold can be important for *index* hospital visits for which there was a positive scaled marginal incentive for improvement on the AMI HRRP measure. In contrast, as anticipated, there was no discontinuity around the 30-day threshold for non-index hospital visits, as they do not face any financial incentives to reduce readmissions for such revisits — within 30 days or otherwise.

Moreover, because the second study population reflects beneficiaries who were initially admitted for an acute myocardial infarction and then returned to a hospital by ambulance within 30 days, this population likely reflects the most serious cases under the HRRP. Nevertheless, the results show that financial incentives under the HRRP influence emergency department and readmission decisions for *even* these cases. This has important implications for the HRRP, as more discretionary cases are even *more* likely to be affected. This means that the care for other beneficiaries returning to a hospital within 30 days (not necessarily by ambulance) following an index HRRP admission for any of the HRRP conditions or procedures is more likely to be influenced under key conditions.

Additionally, because this second study population likely reflects the most serious cases under the HRRP, the reported hospital quality measures would be *even more* affected for other

HRRP patients and conditions. An increase in the distortion in the HRRP measures further increases risk of penalties and negative quality perceptions for *only* the *index* hospital — for readmission decisions outside of their direct control. This further undermines the aims of publicly reported HRRP performance: (1) to enable patients to make informed health care decisions by providing quality of care information, as well as (2) to incentivize investment in quality across providers by introducing quality competition. In turn, given the money at stake, all of this translates into meaningful differences in financial penalties *due simply* to patients returning to hospitals lacking *any* incentives to curtail readmissions (rather than the original hospital).

This study is limited to one HRRP condition and to patients who return to the hospital by ambulance for the analyses of patients returning to any hospital. As a result, this is not the full set of HRRP conditions and procedures, so it is not the full picture of the magnitude of HRRP effects across all patients. However, this study estimates the causal effect of HRRP incentives and addresses patient selection of hospitals, and to the extent that the study population reflects the most serious cases, this then reflects conservative estimates. Although this research focuses on the Medicare FFS population, this is exactly the population targeted by the HRRP. Future research on spillovers to other populations, such as Medicare Advantage beneficiaries, would also be valuable.

Third, this research finds that such readmission reductions resulting from the incentives underlying the HRRP did not lead to a statistically significant increase in mortality among the AMI HRRP population. This is noteworthy as the return study population likely reflects the most serious cases, suggesting that there may be leeway to further reduce readmissions across the

board in terms of distinct populations or conditions. However, because there is a wide confidence interval for the mortality result, this cannot be interpreted as a precise zero.

Fourth, evidence from this study sheds light on why *overall* readmission reductions have been less pronounced to date than expected, since patient readmissions at hospitals lacking financial incentives to curtail readmissions are common. This includes not only readmissions at *index* hospitals for which the hospital-specific marginal incentive for improvement on the AMI HRRP measure is zero, but also *all* readmissions at *non-index* hospitals which always face zero financial incentives to curtail such readmissions. Because 29.5 percent of patients return to a hospital within 30 days overall (regardless of mode of transportation or readmission), it is important to focus not only on the care at the time of the initial admission but also on the return hospital's emergency department, observation stay, and readmission decisions, conditional on patients returning to a hospital within 30 days. Because numerous hospitals to which patients may visit following discharge face zero marginal incentive for improvement on the AMI HRRP measure, this changes the incentives of the index hospital to invest effort in curtailing readmissions, particularly if the investments constitute considerable time, effort, or resources. In turn, this further diminishes the effect the HRRP could otherwise have, as a result of the muted financial incentives faced by return hospitals.

Fifth, this research further shows how even relatively subtle policy design components can create crucial incentives that shape the way stakeholders respond, sometimes in unexpected ways, and in turn, this has significant real-world consequences for vital hospital, patient, and payer outcomes. In particular, this research shows how differing incentives across hospitals influence hospital revisits as well as readmission and emergency department decisions; distort

the signal of hospitals' readmission rates; increase unnecessary spending; as well as alter reported hospital performance.

Sixth, this research builds on prior research and addresses gaps. As noted, this research is the first to exploit *exogenous variation* in hospital incentives to obtain *causal estimates* of the effects of the HRRP on patients, Medicare, and hospitals. There is variation in treatment of *index* versus *non-index* hospital visits from before to after the HRRP, along with variation in the magnitude of the hospital-specific marginal incentive. It further sheds light on why overall readmission reductions are less pronounced than what many people expected because many return hospital visits are not subject to financial incentives. Investigating concerns overall across hospitals—without accounting for whether the given hospital would be penalized for its readmission decision for the given patient (due to its index or non-index status)— masks critical heterogeneity across index and non-index hospitals in light of distinct incentives they face under the HRRP. This research also builds on prior research that has shown that pay-for-performance incentives can negatively affect specific subpopulations or lead providers to treat patients in unintended ways in light of the incentives (Gupta, Fonarow, 2018; Wadhera, Yeh, Joynt Maddox, 2019; Huckfeldt, Escarce, Sood, Yang, Popescu, Nuckols, 2019; Wadhera, Joynt Maddox, Wasfy, Haneuse, Shen, Yeh, 2018; Samarghandi, Qayyum, 2019; Gupta, Allen, Bhatt, Cox, DeVore, Heidenreich, Hernandez, Peterson, Matsouaka, Yancy, Fonarow, 2018; Albritton, Belnap, Savitz, 2018; Puebla Neira, Hsu, Kuo, Ottenbacher, Sharma, 2020; Nathan, Martinez, Giri, Navathe, 2020; Albritton, Belnap, Savitz, 2017; Wadhera, Joynt Maddox, Kazi, Shen, Yeh, 2019; Krumholz, Lin, Keenan, Chen, Ross, Drye, Bernheim, Wang, Bradley, Han, Normand, 2013; Chatterjee, Joynt Maddox, 2018; Fonarow, Ziaeian, 2019; Gupta, Fonarow, 2018; Jha, 2018; Huckfeldt, Escarce, Wilcock, Sood, Rabideau, Popescu, Nuckols, 2018; Fuller, Hughes,

Goldfield, Averill, 2018; Fonarow, Konstam, Yancy, 2017). Several studies found an increase in mortality following HRRP introduction for heart failure or pneumonia patients (Wadhera, Joynt Maddox, Wasfy, Haneuse, Shen, Yeh, 2018; Gupta, Allen, Bhatt, Cox, DeVore, Heidenreich, Hernandez, Peterson, Matsouaka, Yancy, Fonarow, 2018; Huckfeldt, Escarce, Wilcock, Sood, Rabideau, Popescu, Nuckols, 2018). In a survey of hospitals, respondents openly admitted that it was "more than moderately likely" that hospitals would avoid high-risk patients and increase the use of observation status to improve their readmission rate (Joynt, Figueroa, Oray, Jha, 2016). Prior research also found that for nonpenalized hospitals, use of observation status depended on whether patients returned before or after the 30-day cutoff (Albritton, Belnap, Savitz, 2018; Albritton, Belnap, Savitz, 2017).

Seventh, this research highlights the role for policy refinement to improve societal outcomes. The HRRP's financial incentives work in that they produce changes in care delivery with increases in the scaled marginal incentives. Yet, because so many hospital revisits are subject to zero marginal incentive for improvement on the AMI HRRP measure, it is critical to ensure that all hospitals face a positive marginal incentive for improvement on this measure if the aim is to further improve readmissions. Additionally, separately reporting and calculating performance on (1) revisits to any hospital, (2) readmissions at index hospitals, and (3) readmissions at non-index hospitals would reduce distortions in the current overall readmission measure and provide clarity on performance that the index hospital has more control over.

Moreover, because the overall probability of readmission is a function not only of (1) the probability of returning to any hospital within 30 days, but also (2) the probability of readmission conditional on returning to any hospital within 30 days, it is essential to provide incentives to reduce both probabilities. Consequently, the return hospital (regardless of index status) needs to

face some financial incentive to reduce readmissions. This change can still permit larger incentives to reduce readmissions among *index* hospitals (compared to *non-index* hospitals) – as long as there is at least *some* incentive to reduce excess readmissions among *all index* and *non-index* hospitals. Additionally, greater scrutiny of the necessity of the given readmission as well as the reason for readmission could provide further incentives to curtail readmissions. Accounting for the reason for readmission could provide further clarity about the extent to which the *index* hospital could reasonably have prevented the readmission without undue burden or unrealistic expectations on the *index* hospital. For example, not only does the HRRP penalize index hospitals for readmissions that occur at hospitals lacking incentives to curtail such readmissions, but it also penalizes *index* hospitals for readmissions unrelated to the cause of the initial admission. Prior research has found that readmission in chronic conditions is pervasive and is often for a different cause other than the cause of the initial admission (Brunner-La Rocca, Peden, Soong, Holman, Bogdanovskaya, Barclay, 2020). Consequently, such oversight of the necessity and cause of given readmissions can in turn shape further refinement of incentives to reduce readmissions across all index and non-index hospitals for distinct types of cases.

Furthermore, hospitals could experience disincentives to invest effort in curtailing readmissions if many of their patients who return to any hospital return to non-index hospitals over which the index hospital has no direct control. Therefore, explicitly rewarding decreases in the risk-adjusted probability of patients returning to the hospital (regardless of readmission) could incentivize investments in effort to curtail revisits and, in turn, readmissions across hospitals.

For example, consider the following case: say the average probability of revisit is 40 percent and the average probability of readmission conditional upon revisiting a hospital is 60

percent, leading to an overall average probability of readmission of 24 percent. Consequently, for hospitals whose beneficiaries returning to hospitals disproportionately return to non-index hospitals (which always face zero financial incentives to curtail such readmissions), then this limits the capability to reduce the 60 percent. As a result, hospitals must rely on reducing the 40 percent to reduce overall readmissions, yet they do not get *explicitly* rewarded or incentivized to reduce revisits.

If there were financial incentives to reduce both probabilities across all hospital revisits, then an average 20 percent reduction in each probability would lead to a resulting overall 15.36 percent probability of readmission ((.32*.48) * 100 = 15.36). However, if the given hospital's patients are disproportionately returning to hospitals with zero marginal incentive to reduce such readmissions, then the 60 percent probability may be largely unchanged so an average 20 percent reduction in the first probability would only lead to a resulting overall 19.2 percent probability of readmission ((.32*.60) * 100 = 19.2).

Furthermore, reducing revisits that would have resulted in emergency department care (but not readmissions) at *index* hospitals with a *positive* marginal incentive or that would have resulted in *any* care at *index* hospitals that have *zero* marginal incentive sacrifices the given index hospital's revenue without producing rewards. Incentivizing reductions in revisits, as well as incentivizing reductions in readmissions conditional on returning to a hospital at *both index* hospitals and *non-index* hospitals will not only more effectively reduce overall readmissions, but also prevent unnecessary procedures for patients and reduce excessive spending.

Together, insights gained from this research can further improve true readmission reductions, Medicare savings, and quality across hospitals, thereby impacting millions of lives.

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Chapter 2: How the Hospital Readmissions Reduction Program Incentives Affect Disparities

2.1 Introduction

Significant health disparities persist in the US and are manifested across wide-ranging conditions and treatment decisions. For example, the American Cancer Society highlights that, of any racial or ethnic group, Black Americans have the shortest survival and highest death rate for most cancers (American Cancer Society). Additionally, compared with White women, Black women are three times more likely to die from a pregnancy-related cause (Centers for Disease Control and Prevention). Moreover, minority racial groups have historically been at greater risk than White patients of being readmitted to a hospital after having recently been discharged (Joynt, Orav, Jha, 2011; Tsai, Orav, Joynt, 2014; McHugh, Carthon, Kang, 2010; Simon, Ho, 2020; Brown, Deng, Becker, Bittner, Levitan, Rosenson, Safford, Muntner, 2015; Pandey, Keshvani, Khera, et. al., 2020; Sabatine, Blake, Drazner, et. al., 2005; Downing, Wang, Gupta, et. al, 2018). The COVID-19 pandemic has further shed light on substantial disparities in health outcomes between patients of different races. Based on age-adjusted COVID-19 mortality data, White Americans have the lowest mortality rate, while mortality rates for Black Americans are at least twice as high (Medicare Payment Advisory Commission, 2021; APM Research Lab, 2021). There has been a long literature on health disparities, which have been found both within hospitals between patients of different races and between hospitals that do and do not disproportionately serve disadvantaged populations.

Understanding effects of health care policy changes on disparities is pivotal for designing refinements to improve outcomes for critical populations. This paper provides new national empirical evidence on how differing incentives across hospitals under the Hospital Readmissions Reduction Program (HRRP) affect disparities. This research will shed light on whether HRRP incentives lessen or exacerbate disparities for racial minority groups (compared to White patients) or for safety-net hospitals (compared to non-safety-net hospitals).

Created by Section 3025 of the Affordable Care Act, the Hospital Readmissions Reduction Program (HRRP) aims to provide financial incentives to curtail hospital readmissions. Under the program, all admissions are classified as either an index admission (which starts a window of accountability) or a readmission (an admission to any hospital within 30-days of discharge from an index admission). The extent to which providers face such incentives and the extent to which providers are responsive to the underlying incentives can both matter in determining the program effect. However, while readmissions to a different (*non-index*) hospital than the *index* hospital historically have been common, *only index* hospitals face financial incentives under the HRRP to avoid readmitting the given patient. *[Note that throughout the paper, hospitals are referred to as index or non-index hospitals for simplicity. However, it is important to keep in mind that this is referring to index versus non-index visits, since index/non-index status is always implicitly defined relative to the given patient. Most hospitals are both index and non-index hospitals over a year, but they are always ONLY one or the other for any specific patient.]*. This results from the treatment of readmissions to *non-index* hospitals under the HRRP. *Non-index* hospital admissions within 30 days of an initial admission are attributed *only* to the *index* hospital's readmission statistics (Rau, 2019; CMS). Consequently, this increases risk of financial penalties and adverse quality perceptions for *only* the *index* hospitals,

even though these readmission decisions are outside the *index* hospital's direct control. Given significant spending at stake, even minor percentage reductions to the base payment amount because of penalization can constitute substantial reimbursement losses to the *index* hospital.

Together, this has significant ramifications for patients, hospitals, and Medicare. In addition to creating unequal comparisons across hospitals and distorting the publicly reported hospital readmission measures, the HRRP may affect disparities. This may occur through different mechanisms that disproportionately affect minority populations at all hospitals or safety-net hospitals, which have lower resources compared to non-safety-net hospitals. Under the first mechanism, providers may respond to underlying HRRP incentives by focusing resources on preventing readmissions among patients perceived to be at highest risk. Since minority patients have historically been at greater risk of readmissions within 30 days, such an approach could potentially decrease persistent disparities. This effect may differ across hospitals.

Second, the extent to which hospitals respond to the underlying incentives may depend on their available resources to invest in preventing readmissions. Specifically, compared to *non-safety-net* hospitals, *safety-net* hospitals may have *less* capacity to invest effort in preventing hospital revisits given that this may be costly in terms of time and resources. As a result of such differences, disparities across hospitals may increase.

Third, as a result of such differences across hospitals, lower-resource hospitals such as *safety-net* hospitals may be at greater risk of penalization and negative quality perceptions. Consequently, to the extent that such hospitals are penalized, they would have even *less* capacity to invest effort in curtailing readmissions. This then would further increase disparities across hospitals. Similarly, if hospitals disproportionately caring for minority patients are penalized,

then they have fewer resources to invest in reducing readmissions, which can increase racial disparities across hospitals (McIlvennan CK, Eapen ZJ, Allen, 2015).

Although some prior research has investigated changes in disparities over time within certain types of hospitals, research to date has not yet fully accounted for the index versus non-index status of such hospital revisits at the patient-level and the lack of incentives faced by non-index hospitals to curtail readmissions. One such study, looking separately at safety-net and non-safety-net hospitals, found increasing racial disparities within safety-net hospitals for non-HRRP-targeted conditions (Chaiyachati, Qi, Werner, 2018). This and other studies did not find changes in disparities for targeted conditions following implementation of penalties, although one study found that racial disparities may have somewhat narrowed before the penalty period (Figueroa, Zheng, Orav, Epstein, Jha, 2018).

Prior research also found that safety-net hospitals have shown improvement in readmission rates (Carey, Lin, 2016; Salerno, Horwitz, Kwon, Herrin, Grady, Lin, Ross, Bernheim, 2017), yet numerous studies have found that, compared to non-safety-net hospitals, safety-net hospitals have been more likely to be penalized (Joynt, Jha, 2013; Figueroa, Wang, Jha, 2016; Gilman, Hockenberry, Adams, Milstein, Wilson, Becker, 2015; Gu, Koenig, Faerberg, Steinberg, Vaz, Wheatley, 2014; Hawn, 2015; Sheingold, Zuckerman, Shartzer, 2016; Thompson, Waters, Kaplan, Cao, Bazzoli, 2017). Most recently, the new HRRP methodology, which determines hospital performance compared to hospitals with a similar percentage of patients dually eligible for Medicare and full Medicaid benefits, may have begun to decrease disproportionate penalties for safety-net hospitals (Wadhera, Yeh, Joynt Maddox, 2019). Other studies have focused on differences in penalization for safety-net or minority-serving hospitals under hypothetical, recent, or upcoming changes to HRRP design (Hsuan, Braun, Ponce,

Hoffman, 2020; Shih, Ryan, Gonzalez, Dimick, 2015; Gaskin, Zare, Vazin, Love, Steinwachs, 2018; Zuckerman, Joynt Maddox, Sheingold, Chen, Epstein, 2017; Joynt Maddox, Reidhead, Hu, Kind, Zaslavsky, Nagasako, Nerenz, 2019; McCarthy, Vaduganathan, Patel, et. al., 2019; Glance, Kellermann, Osler, Li, Li, Dick, 2016), such as adjusting for social factors or including CABG surgery. While some additional studies also examined disparities, they have focused on a few states (Kaplan, Thompson, Waters, 2019), on conditions for which results may not generalize to critical HHRP patient populations, or a subset of hospitals stratified by whether they were initially penalized (Pandey, Keshvani, Khera, et. al., 2020; Radford, 2020).

Yet, as minority groups have historically been at greater risk of being readmitted (Joynt, Orav, Jha, 2011; Tsai, Orav, Joynt, 2014; McHugh, Carthon, Kang, 2010; Simon, Ho, 2020; Brown, Deng, Becker, Bittner, Levitan, Rosenson, Safford, Muntner, 2015; Pandey, Keshvani, Khera, et. al., 2020; Sabatine, Blake, Drazner, et. al., 2005; Downing, Wang, Gupta, et. al, 2018), it is critical to further understand whether differing HRRP incentives across hospitals lessen or exacerbate disparities. As noted above, the HRRP could affect hospital responsiveness to underlying incentives by preventing readmissions among minority populations. It is further important to understand how safety-net hospitals which have limited resources and serve more disadvantaged populations respond to the underlying incentive design (compared to non-safety-net hospitals), as well as how resulting penalties under the HRRP affect disparities across hospitals. This study addresses these research gaps. It investigates whether there are changes in the probability of returning to any hospital, by patient race within all hospitals or for safety-net hospitals compared to non-safety-net hospitals, with increases in the incentive to improve on the readmissions measure. Additionally, it investigates whether changes in readmission decisions for index versus non-index hospitals post-HRRP implementation differ for minority patient

populations within hospitals as well as for safety-net hospitals compared to non-safety-net hospitals, with increases in the incentive to improve. In other words, conditional on returning to any hospital in 30 days, where hospital choice is effectively randomized by ambulances, is there differential treatment by race or safety-net status with increases in the incentive to improve on the readmissions measure? This research investigates the potential mechanisms for changes in disparities as well as whether the HRRP lessened or exacerbated disparities.

This is the first study to exploit exogenous variation in incentives introduced by distinct treatment of index versus non-index hospital visits to address critical unanswered questions about the effects of readmission incentive design on disparities. This research builds on previous research that has found that although readmissions have decreased following HRRP implementation (Wasfy, Zigler, Choirat, Wang, Dominici, Yeh, 2017; Angraal, Khera, Zhou, et. al., 2018; Zuckerman, Sheingold, Orav, Ruhter, Epstein, 2016; Medicare Payment Advisory Commission, 2018), a considerable portion of these reductions can be explained by hospital upcoding, increasing patients' coded level of severity, which artificially lowers hospitals' 30-day risk standardized readmission rates without *true* readmission reductions (Ibrahim, Dimick, Sinha, Hollingsworth, Nuliyalu, Ryan, 2018; Ody, Msall, Dafny, Grabowski, Cutler, 2019; Gupta, Fonarow, 2018; Wadhera, Yeh, Joynt Maddox, 2019). Moreover, this research also builds on prior research *[dissertation paper 1]* that provided new national empirical evidence further shedding light on why *overall true* readmission reductions have been less pronounced to date (Ibrahim, Dimick, Sinha, Hollingsworth, Nuliyalu, Ryan, 2018; Ody, Msall, Dafny, Grabowski, Cutler, 2019; Gupta, Fonarow, 2018; Sandhu, Heidenreich, 2019; Samsky, Ambrosy, Youngson, Liang, Kaul, Hernandez, Peterson, McAlister, 2019), since patient readmissions at hospitals lacking financial incentives to reduce readmissions are pervasive. This study elucidates whether

the HRRP incentive design lessened or exacerbated disparities. It quantifies the extent to which differential HRRP incentives affect outcomes for minority patient populations and for safety-net and non-safety-net hospitals. In turn, it also makes policy recommendations to address concerns. The results could lead to improvements in health care quality and disparities across hospitals.

2.2 Conceptual Framework

To first illustrate, consider the hypothetical cases of Adam, Bob, Casey, and Daniel, who all live in the same small city with two hospitals. All are in their late 60's and recently were admitted to the closest hospital (based on the location they happened to be in the city at the time) after suffering an acute myocardial infarction. Adam and Bob were discharged from a *safety-net hospital*, whereas Casey and Daniel were discharged from a *non-safety-net hospital*. About two weeks later, all four people suffered similar symptoms and an ambulance brought them to the closest hospital to their home. Based on their location at the time, Adam and Casey ended up at the *safety-net hospital (the index hospital for Adam, and a non-index hospital for Casey)*, while Bob and Daniel ended up at a *non-safety-net hospital (the index hospital for Daniel, and a non-index hospital for Bob)*. Based on their severity, all these cases allowed discretion on the part of the hospital to which they returned about whether to admit the given patient.

The *non-safety-net hospital* has abundant resources and an analytics department that analyzes how its readmission decisions can augment its profit. In contrast, the *safety-net hospital* has financial challenges and was further strained from being penalized under the HRRP. Consequently, the *safety-net hospital* has fewer resources to invest in preventing readmissions, and it ended up subsequently admitting both Adam and Casey. Because Adam was previously admitted at the *safety-net hospital*, the *safety-net hospital* was the *index* hospital, so this second

admission counted as a readmission against the *safety-net hospital*. In contrast, because Casey was recently admitted at a different hospital, the *safety-net hospital* was the *non-index* hospital, so this second admission counted as a readmission only against the *non-safety-net hospital*.

In contrast, the *non-safety-net hospital* saw that Daniel had recently been admitted at its hospital and that based on their analyses additional AMI readmissions would very likely lead to penalization. To avoid a readmission, they kept him overnight in an observation stay and then sent him home. Because he was not readmitted, this case did *not* count against the *non-safety-net hospital*. In contrast, because Bob had *not* previously been admitted there, the *non-safety-net* providers were *not* concerned about avoiding an admission and consequently admitted him. However, because he was recently admitted at a different hospital, the *non-safety-net hospital* was the *non-index* hospital, so this second admission counted as a readmission against the *safety-net hospital (and not the non-safety-net hospital)*. In contrast, the *non-safety-net hospital* benefited from the higher reimbursement from an admission, without any risk of being penalized.

Despite the fact that all four people suffered similar symptoms again and returned to a hospital within 30 days, the *safety-net hospital* was more adversely affected, increasing risk of further financial penalties and strain. The HRRP may unintentionally exacerbate disparities. This research tests the effects of differing HRRP incentives on disparities.

Under the HRRP, hospitals that are determined to have excessive 30-day readmissions to any hospital for targeted conditions or procedures consequently experience reduced payments applied to all their Medicare fee-for-service (FFS) base operating diagnosis-related group (DRG) payments. The HRRP was created by the ACA, but the final details were not formally announced until the August 2011 Federal Register Final Rule. Although penalties began FY2013, penalties

were calculated based on prior performance, so hospitals had an incentive to react immediately to the 2011 announcement. From the start, the applicable conditions and procedures included acute myocardial infarction, heart failure, and pneumonia, comprising over 10 percent of Medicare inpatient stays and some of the most expensive conditions (Liang, Moore, Soni, 2020). Since then, they have expanded to include chronic obstructive pulmonary disease (COPD), hip or knee replacement, and coronary artery bypass graft (CABG) surgery. These procedures are among the most frequent surgeries overall, with hip and knee replacement as the most common surgeries for Medicare beneficiaries (CMS). They also reflect some of the most expensive procedures (McDermott, K.W. & L. Liang, 2021). The maximum penalty has also risen from 1% of all of a given hospital's Medicare FFS base payments in FY 2013, to 2% in FY 2014, and then to 3% in all subsequent years. Recently, the 21st Century Cures Act modified the HRRP payment reduction methodology from a non-stratified methodology (FYs 2013-2018) to a stratified methodology (FY 2019 and onward), meaning that the given hospital's performance is determined compared to hospitals with a similar percentage of patients who are dually eligible for Medicare and full Medicaid benefits (Centers for Medicare & Medicaid Services). Equations 1 and 2 below show the HRRP formulas used to calculate the percent (*P*) of DRG payment that the hospital will receive after subtracting the HRRP-specific penalty (Centers for Medicare & Medicaid Services, 2017). In the equations, *dx* reflects the HRRP-targeted condition or procedure, payments refer to base operating DRG payments, and ERR refers to the hospital's condition-specific excess readmissions ratio, which captures its performance on the given measure. The numerator of the ERR reflects the actual adjusted number of readmissions for that hospital. It is calculated by estimating the probability of readmission for each patient who qualifies for that measure at that hospital and summing up these probabilities over all these

patients. The denominator of the ERR reflects the expected number of readmissions. It is calculated by summing the probability of readmission for these same patients as if they were treated at an average quality hospital. Therefore, readmission measure results reflect the given hospital's performance compared to the performance of an average hospital treating comparable patients. Approximately half of hospitals will have higher actual adjusted readmission rates than expected readmission rates for a given condition or procedure each year, and therefore receive a penalty. CMS uses a rolling three-year performance period to calculate readmission measures (Maurer, Peris, Bunch, 2020). As a result, hospitals have an idea of how well they are performing and their expected readmissions over time.

Also as reflected in the equation, any condition or procedure with an ERR of 1 or less will drop out of the equation, since the hospital performed as well or better than expected on the given measure. Furthermore, only measures based on more than 24 discharges for the given condition or procedure are included for the given hospital. As shown here, the overall penalty is capped at 3 percent in later years (while it was smaller in earlier years). Under the revised, stratified HRRP methodology, the dual eligible proportion is calculated for each hospital. Hospitals are then stratified into 5 peer groups, and the median ERR for the given peer group enters the equation. The neutrality modifier refers to the factor that equates payments under the stratified methodology to payments under the unstratified methodology.

Equation 1 reflects the equation under the original HRRP methodology.

$$(1) \qquad P = 1 - min\left\{.03, \sum_{dx} \frac{Payment_{dx} \times \mathbf{1}(\#Discharge_{dx} > 24) \times max\{(ERR_{dx} - 1), 0\}}{All\ Payments}\right\}$$

Equation 2 reflects the equation under the revised, stratified HRRP methodology.

$$(2)\ P = 1 - min\left\{.03, \sum_{dx} \frac{(Neutrality\ modifier) \times Payment_{dx} \times \mathbf{1}(\#Discharge_{dx} > 24) \times max\{(ERR_{dx} - peer\ group\ median\ ERR), 0\}}{All\ Payments}\right\}$$

However, only the *index* hospital faces any financial incentives under the HRRP to avoid readmitting the given patient. It established different financial consequences depending on whether patients are readmitted to the same (*index*) or to a different (*non-index*) hospital. If a patient returns to the *index* hospital within 30 days and gets readmitted, the *index* hospital is at risk of penalization and negative quality perceptions. The penalty for each excess readmission of a patient with a heart failure, hip replacement, or knee replacement initial admission, is approximately *five to twenty times larger* than the reimbursement from the initial admission (Medicare Payment Advisory Commission, 2018). Consequently, for *index* hospitals post-HRRP implementation, any positive direct financial incentive to admit such patients is undermined by the negative indirect financial incentive (i.e., decrease in all Medicare FFS payments for their hospital as a result of excess readmissions of such patients). However, if the *index* hospital instead treats the given patient through the emergency department or an observation stay, this does *not* count against the *index* hospital. Consequently, the *index* hospital faces an incentive to curtail readmissions, and instead treat the given patient through the emergency department or an observation stay.

Yet, if a patient returns to a *non-index* hospital within 30 days, the *non-index* hospital has *no* financial incentive to avoid a readmission. The *non-index* hospital can instead readmit *all* such patients with *zero* risk of penalization or negative quality perceptions. Consequently, the *non-index* hospital not only gains reimbursement for readmitting such patients (positive direct financial incentive), but it also avoids a reduction in all Medicare FFS payments from excess readmissions of such patients (non-negative indirect financial incentive). As a result of readmitting the given patient, the *non-index* hospital gains higher reimbursement through the

readmission (compared to treating patients through the emergency department or an observation stay) and its reported readmission rate is unaffected. In contrast, the readmission rate for the *index* hospital worsens and the *index* hospital is at risk of penalization and negative quality perceptions — for a readmission decision outside of its direct control and *not* subject to any HRRP financial incentives.

While *all non-index* hospitals (as defined relative to the given patient) face *zero* financial incentives to avoid such readmissions, the magnitude of incentives for avoiding such readmissions varies among *index* hospitals. However, there is always an important distinction between whether a hospital is an *index* or *non-index* hospital relative to the given patient. In contrast with *non-index* hospitals, *index* hospitals with zero financial marginal incentive may still face incentives for improving performance. This includes hospital reputation under public reporting, uncertainty, and feeling responsible for patients first admitted there while being primed to be more cautious about readmissions.

While hospitals always experience larger incentives to avoid admitting patients recently admitted at their own hospital (compared to patients recently admitted at other hospitals), those with larger incentives for improving on a given readmission measure may improve even more. Indeed, [dissertation paper 1] found that for AMI beneficiaries returning to a hospital within 30 days, hospitals respond by differentially increasing emergency department care and reducing readmissions for *index* hospital visits (compared to *non-index* hospital visits) post-HRRP implementation, with increases in the *index* hospital-specific scaled marginal incentive to improve on the AMI HRRP measure.

Yet, with HRRP implementation, there may be important changes in disparities across hospitals, affecting patients of different races as well as safety-net and non-safety-net hospitals.

This could occur through different mechanisms. First, providers facing incentives to curtail readmissions may focus the greatest effort towards patients perceived to be most at-risk. Not only would such an approach reach those most vulnerable, but it may also be more cost-effective. Because minority patients historically have been at greater risk of being readmitted within 30 days, this could potentially reduce disparities. This effect could differ across hospitals, such as *safety-net* and *non-safety-net* hospitals. Depending on how this is achieved, this may or may not improve patient outcomes. For example, if hospitals implement changes to disproportionately reduce the probability that Non-White patients return to any hospital within 30 days through improved discharge processes and follow-up, this could improve care. However, if hospitals disproportionately reduce the probability of readmitting Non-White patients, conditional on the patients returning to a hospital, this could potentially have adverse consequences. This could potentially forgo needed care. This could also subject the patients to higher financial liability, including higher out-of-pocket costs for their hospital care or preclude Medicare coverage of subsequent post-acute care.

Second, responsiveness to the underlying incentives may depend on the extent to which the given hospital has sufficient resources to invest in preventing readmissions. In particular, compared to *non-safety-net* hospitals, *safety-net* hospitals may be *less* able to invest effort in preventing hospital revisits given more limited resources. This is especially the case given that such efforts may be costly in terms of time and resources. Consequently, disparities across hospitals can increase due to differences in the capacity to invest in preventing readmissions.

Third, because of such differences across hospitals, lower-resource hospitals such as *safety-net* hospitals may be at greater risk of penalization and negative quality perceptions. In turn, already lower-resource hospitals that are penalized have even *less* capacity to invest in

quality, thereby further exacerbating disparities across hospitals. Similarly, if hospitals disproportionately caring for minority patients are penalized, they would have fewer resources to invest in curtailing readmissions, which can exacerbate racial disparities across hospitals.

This research therefore tests whether the HRRP alleviated or exacerbated disparities in readmission decisions. For each outcome of interest *Y*, it investigates whether there was heterogeneity in the treatment effect by patient race or safety-net hospital status. In particular, for minority patients (compared to non-minority patients) across all hospitals or safety-net hospitals (compared to non-safety-net hospitals), this research estimates whether there were changes in the probability of returning to any hospital within 30 days, with increases in the marginal incentive to improve on the readmissions measure. Additionally, it investigates the differential change in the outcome for patients returning to index versus non-index hospitals, from before to after HRRP implementation, and how this effect increased with the hospital-specific marginal incentive for improvement. This research not only exploits variation in incentives between index and non-index hospitals (as defined relative to the given patient) from before to after HRRP implementation, but it also exploits variation in the magnitude of the hospital-specific marginal incentive.

Specifically, the underlying model includes terms capturing (1) whether the given treatment effect differed for minority patients (compared to non-minority patients) or for safety-net hospitals (compared to non-safety-net hospitals), indicating heterogeneity in treatment effects, and (2) whether there was a difference for minority patients (compared to non-minority patients) or for safety-net hospitals (compared to non-safety-net hospitals) in how the treatment effect changes with increases in the hospital-specific marginal incentive. The treatment effect reflects whether the outcome differentially changed for patients returning to index versus non-

index hospitals (as defined relative to the given patient) after HRRP implementation. In all applicable analyses, this research controls for patient demographic and severity variables, hospital characteristics, as well as quarter-year and hospital fixed effects. The analyses comparing safety-net and non-safety-net hospitals, however, consequently omit hospital fixed effects. Rigorous methods to account for patient selection of hospitals are also used, discussed in more detail in the methods section. After identifying all admissions for AMI, the main approach restricts to beneficiaries who return to *any* hospital within 30 days by ambulance, where hospital choice is effectively randomized by ambulances, using an instrumental variables approach. Moreover, this study focuses on AMI, a targeted HRRP condition and an emergent condition for which hospital distance is critical.

2.3 Methods

2.3.1 Analytic Approach

First, this study calculates the hospital-specific marginal incentive (Norton et al., 2018; Norton, Lawton, Li, 2023) for improvement on the given readmissions measure for each hospital and time period. The hospital-specific marginal incentive for each condition measures how much an improvement in the condition-specific readmission would affect performance, and subsequently Medicare reimbursement. Because hospitals vary in their percentage of patients covered by Medicare, hospitals with greater dependence on Medicare revenue may be more responsive to financial incentives targeting the Medicare population. To account for this, the hospital-specific marginal incentive to improve is subsequently scaled by the hospital's Medicare percentage of inpatient days in the given time period in all models.

Using national data, this research investigates whether the HRRP alleviated or exacerbated disparities in key outcomes. Specifically, this research investigates differences for minority patient populations as well as for safety-net hospitals in how readmission decisions changed across index and non-index hospitals following HRRP implementation. It separately estimates the effects on minority patient populations, compared to non-minority patient populations, across all hospitals and the effects on safety-net hospitals, compared to non-safety-net hospitals. Since only index hospitals face financial incentives to reduce readmissions, the hospital marginal incentive is captured separately for index and non-index hospitals. This research conducts difference-in-differences analyses with adjustments for the magnitude of the hospital-specific marginal incentive. The difference-in-differences analyses control for time trends and compare changes in the key outcomes between the pre-HRRP and post-HRRP implementation time periods.

There are three sets of outcomes. The first reflects the probability of patients returning to *any* hospital within 30 days of an AMI HRRP initial admission (regardless of whether they were then readmitted). The second reflects the probability of a readmission, conditional on returning to *any* hospital within 30 days. Third, there are two outcome measures that reflect reported hospital measures: changes in (1) hospitals' measure-specific performance and (2) overall HRRP performance as a result of the change in their readmission rate due to a change in AMI readmissions from beneficiaries who return to *any* hospital within 30 days being treated like beneficiaries returning to the *index* hospital.

For each outcome of interest *Y*, this research investigates whether there was heterogeneity in the treatment effect by patient race or safety-net hospital status. Specifically, for minority patients (compared to non-minority patients) or safety-net hospitals (compared to non-safety-net

hospitals), it estimates the differential change in the outcome for patients returning to index versus non-index hospitals, from before to after HRRP implementation, with adjustments for the magnitude of the hospital-specific marginal incentive for improvement.

There are two key explanatory measures of interest. These two measures build on those from prior research *[dissertation paper 1]*. In this prior research, the first had reflected whether there is a difference between index and non-index hospitals after HRRP implementation, for hospitals with zero financial marginal for improvement under the HRRP, but who are still subject to public reporting of performance. This reflected a basic difference-in-differences model. The second had reflected whether the previous effect increases with the hospital-specific marginal incentive. This reflected a difference-in-difference-in-differences model. The present research investigates whether these effects differ for minority patients (compared to non-minority patients) or for safety-net hospitals (compared to non-safety-net hospitals). As a result, in the present research, the preceding key explanatory measures of interest are interacted with an indicator for minority patient or safety-net hospital (depending on the model specification). Consequently, the resulting first explanatory measure of interest reflects a triple difference-in-differences, while the resulting second explanatory measure of interest reflects a quadruple difference-in-differences. The *Data Sources, Study Population, and Measures* section describes how minority patients and safety-net hospitals are defined in the analyses.

Additionally, all analyses control for patient demographic and severity variables, hospital characteristics, as well as quarter-year and hospital fixed effects (except for analyses comparing safety-net and non-safety-net hospitals, which omit hospital fixed effects). For all analyses, cluster-robust standard errors are estimated to account for repeated observations within hospitals.

The following reflects the main regression model at the patient level for patient *i*, hospital *j*, and time-period *t* for patients returning to *any* hospital within 30 days of the given AMI admission (Equation 3). This specification incorporates an indicator variable for whether the return hospital visit is (1) by a minority patient (equation 3 below) or (2) to a safety-net hospital (analogous to equation 3).

$$
\begin{aligned}
(3)\ Y_{i,j,t} = {} & \beta_0 + \beta_1 IndexHospital_{i,t} + \beta_2 Post_t \\
& \qquad \text{[Difference-in-Differences]} \\
& + \beta_3 IndexHospital_{i,t} \times Post_t \\
& + \beta_4 HospMarginalIncentive_{j,t} \\
& + \beta_5 HospMarginalIncentive_{j,t} \times IndexHospital_{i,t} \qquad \text{[Difference-in-Difference-in-Differences (with Hospital-Specific Marginal Incentive)]} \\
& + \beta_6 HospMarginalIncentive_{j,t} \times Post_t \\
& + \beta_7 IndexHospital_{i,t} \times Post_t \times HospMarginalIncentive_{j,t} \\
& + \beta_8 MinorityPatient_{i,t} + \beta_9 IndexHospital_{i,t} \times MinorityPatient_{i,t} \qquad \text{[Quadruple Difference-in-Differences (with Minority Patients)]} \\
& + \beta_{10} Post_t \times MinorityPatient_{i,t} + \beta_{11} HospMarginalIncentive_{j,t} \times MinorityPatient_{i,t} \\
& \mathbf{+ \beta_{12} IndexHospital_{i,t} \times Post_t \times MinorityPatient_{i,t}} \\
& + \beta_{13} HospMarginalIncentive_{j,t} \times IndexHospital_{i,t} \times MinorityPatient_{i,t} \\
& + \beta_{14} HospMarginalIncentive_{j,t} \times Post_t \times MinorityPatient_{i,t} \\
& \mathbf{+ \beta_{15} IndexHospital_{i,t} \times Post_t \times HospMarginalIncentive_{j,t} \times MinorityPatient_{i,t}} \\
& + \beta_{16} X_{i,t} + \beta_{17} H_j + \beta_{18} (Quarter \times Year_t) + \beta_{19} \lambda_j + \varepsilon_{i,j,t} \qquad \text{[Additional Controls]}
\end{aligned}
$$

where $IndexHospital_{i,t}$ reflects whether the hospital to which the patient returned was the index hospital (or, in sensitivity analyses, a hospital within the same hospital system as the index hospital), $Post_t$ is whether the time period was after HRRP implementation, $MinorityPatient_{i,t}$ reflects whether the patient was a Black patient (or a Non-White patient, in sensitivity analyses), $HospMarginalIncentive_{j,t}$ is the hospital-specific marginal incentive for improvement on the AMI readmissions measure, $Quarter_t \times Year_w$ is the time period that the visit occurred, $X_{i,t}$ is a vector of patient characteristics (age, gender, race, dual eligibility, severity (based on Hierarchical

Condition Category and Elixhauser Comorbidity Index approaches)), H_j is a vector of hospital characteristics (such as size and Disproportionate Share Hospital (DSH) percent), λ_j reflects hospital fixed effects (except for analyses comparing safety-net and non-safety-net hospitals), and $\varepsilon_{i,j,t}$ is an error term.

The first coefficient of interest is the coefficient on the triple interaction between index hospital, post-period, and minority patient (β_{12}). For each outcome, this coefficient of interest captures whether the given treatment effect differed for minority patients (compared to non-minority patients) or for safety-net hospitals (compared to non-safety-net hospitals), indicating heterogeneity in treatment effects. Specifically, this term reflects an interaction between a treatment effect of interest and an indicator variable for whether the return hospital visit is (1) by a minority patient (equation 3) or (2) to a safety-net hospital (analogous to equation 3). The treatment effect of interest captures whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation, for hospitals with zero financial marginal for improvement under the HRRP, but who are still subject to public reporting of performance.

The second coefficient of interest is the coefficient on the quadruple interaction between index hospital, post-period, hospital-marginal incentive, and minority patient (or safety-net hospital, depending on the specification) (β_{15}). This captures whether there was a difference for minority patients (compared to non-minority patients) or for safety-net hospitals (compared to non-safety-net hospitals) in how the treatment effect changes with increases in the hospital-specific marginal incentive. The treatment effect reflects whether the outcome differentially changed for patients returning to index versus non-index hospitals after HRRP implementation.

If the coefficient is positive for readmissions models, then the given treatment effect was larger for non-minority patients or for non-safety-net hospitals, reflecting increasing disparities. Understanding whether responses to underlying HRRP incentives may have exacerbated disparities, and through which mechanisms, is vital to improve patient outcomes.

In addition, after identifying all admissions for AMI, this research accounts for patient selection of hospitals. For example, patients may choose hospitals because of the given hospital's perceived quality or capabilities. This means that high quality hospitals may end up treating the most complex or sickest cases in the geographic area. On the other hand, patients who choose hospitals perceived to be higher quality may be more savvy consumers of health information and in better health. It is necessary to address patient selection of hospitals to avoid selection bias.

The main method of addressing patient selection uses an instrumental variables approach that builds on the work of Doyle and colleagues (Doyle, Graves, Gruber, Kleiner, 2015; Doyle, Graves, Gruber, 2019). It identifies beneficiaries who return to *any* hospital within 30 days by ambulance and restricts analysis to just them. Whereas including all beneficiaries regardless of location of residence and method of travel to the hospital could introduce situations where patients' hospital choice is not random, restricting to beneficiaries brought by ambulance removes this selection. Specifically, as discussed in the Doyle et al. paper, the ambulance company dispatched to the given patient is effectively random because of rotational assignment or even direct competition between simultaneously dispatched companies. Additionally, ambulance companies that serve the same area have preferences regarding which hospital they transport patients. Consequently, the choice of hospital is not based on quality but instead is effectively random based on the ambulance company and distance to the nearest hospital. The instrument for whether the given patient returned to the index hospital or a non-index hospital is

the percent brought to the hospital the given patient visited for the initial admission (the given *index* hospital). The instrument denominator is all other patients picked up by the same ambulance company. Furthermore, there are several additional instruments. This is because the endogenous variable, which reflects whether the given patient returns to the index or a non-index hospital, is interacted with other variables in the model. As a result, there is also one corresponding instrument for each endogenous interaction term. Moreover, all analyses focus on the AMI HRRP measure because AMI reflects an emergent condition for which hospital distance is critical.

These methods together provide alternative specifications to account for hospital selection and avoid instances of endogenous hospital choice. These approaches are preferable to other approaches, such as using differential distance more broadly as an instrumental variable, which may not fully account for hospital selection based on quality. If differential distance as an instrumental variable were instead used, there could be remaining concerns about areas in which there are a lot of nearby hospitals, where it is possible that the hospital choice could still be endogenous. In contrast, the proposed methods address that source of selection bias, and because the HRRP is a mandatory program, this eliminates selection bias that would exist among hospitals opting to participate in voluntary programs.

2.3.2 Data Sources, Study Population, and Measures

To investigate how changes in readmission decisions across index and non-index hospitals differ for minority patient populations as well as for safety-net hospitals, this research needs national data on hospital visits for Medicare beneficiaries before and after HRRP implementation. It also needs information on provider readmission decisions; patient demographics; patient severity; whether a given patient was brought to the hospital by

ambulance; zip code of residence; as well as timing and location of visits and stays. Additionally, for every hospital, it needs data on hospital characteristics, HRRP performance, and previous payment adjustments resulting from the HRRP to control for these factors in the analyses.

This research uses claims data from a national random 20% sample of Medicare beneficiaries to identify hospital visits; whether a given hospital reflects an index or non-index hospital; readmission decisions; patient demographics; patient severity; whether a given patient was brought to the hospital by ambulance; hospital region; patient zip code of residence; and the time period and location of the visit or stay. To identify and control for hospital characteristics such as number of beds, Medicare share of inpatient days, and Disproportionate Share Hospital (DSH) percent, this research supplements the data with the Impact File, the Provider of Services File, and the American Hospital Association Annual Survey. To additionally incorporate hospital-specific incentives, this research uses lagged HRRP performance data for each hospital and time frame from the main and supplemental HRRP data files.

This study focuses on AMI patients because AMI reflects a targeted condition under the HRRP; an emergent condition for which hospital distance is critical; a common, costly condition; as well as a condition responsible for frequent readmissions, including a considerable number to non-index hospitals. Among AMI patients, there are two study populations which focus on the population targeted by the HRRP. Specifically, this research identities all Medicare beneficiaries (1) older than 65, (2) discharged in 2009-2017 from an *HRRP AMI initial admission* at a hospital that consistently met the minimum case requirements of at least 25 discharges to receive an HRRP AMI measure score, (3) who were continuously enrolled in Part A and Part B of FFS Medicare for the full 12 months leading up to the initial admission and enrolled in Part A during the initial admission, (4) were not transferred to another acute care facility, and (5) were alive at

discharge. This incorporates criteria for beneficiaries admitted for an AMI to be included under the HRRP. Together, the above criteria comprise the *first study population*, which is used in the probability of a revisit to *any* hospital (regardless of readmission) within 30 days analysis.

Additionally, for the analyses *conditional on returning to any hospital*, the above study population was restricted to a *second study population*. Specifically, the second study population reflects patients who had a revisit to *any* hospital (that consistently met the minimum case requirements of at least 25 discharges to receive an HRRP measure score) within 30 days by ambulance (regardless of whether they were readmitted).

Consistent with prior literature, this research defines minority patients as Black patients. In sensitivity analyses, this research defines minority patients more broadly as all Non-White patients. Because safety-net status is not officially designated by CMS, this research defines safety-net hospitals based on recent literature (Chatterjee, Joynt, 2014; Gilman, Adams, Hockenberry, Wilson, Milstein, Becker, 2014; Gilman, Hockenberry, Adams, Milstein, Wilson, Becker, 2015; Mohan, Grant, Batalden, McCormick, 2013) using the Impact File. Accordingly, this research calculates the average value of the percentage of disproportionate share hospital (DSH) adjustment and the average amount of Medicare uncompensated care per claim (UCC) across all data years by hospital. Then, it characterizes hospitals as safety-net if their DSH or UCC average is in the top quartile of DSH or UCC, respectively, across the national sample.

2.4 Results

2.4.1 Beneficiary and Hospital Characteristics of Beneficiaries Returning to Any Hospital by Ambulance Within 30 Days

Table 2.1: Key Patient and Hospital Characteristics Over Study Time Frame, Beneficiaries Discharged in 2009-2017 From an HRRP AMI Index Admission Who Then Had Revisit to a Hospital Within 30 Days by Ambulance (Regardless of Whether Readmitted)

Key Patient Characteristics, Over Full Time Period	***n***	***%***
Gender		
Female	13,506	54.4
Male	11,317	45.6
Race		
White	21,434	86.4
Black	2,217	8.9
Hispanic	490	2.0
Other	682	2.8
Dually Eligible in Original Hospital Discharge Month		
Not dually eligible	19,613	79.0
Dually eligible	5,210	21.0
Any ICU Days During Original Admission		
No ICU Days	11,821	47.6
Any ICU Days	13,002	52.4
Mean HCC Community Score	3.3	
Median Index Hospital Length of Stay (in Days)	4.0	
Mean Age at End of Reference Year	80.5	
Key Characteristics of Most Recent Hospital	***n***	***%***
Hospital Size		
<100 Beds	1,199	4.8
100-299 Beds	11,535	46.5
300+ Beds	12,089	48.7
Teaching Affiliation	14,348	57.8
For-Profit Hospital	3,638	14.7
Safety-Net Hospital	7,857	31.7
Received Penalty Based on:		
AMI Performance in Prior Year, in Penalty Period	5,740	50.3
Performance on Any of the Measures in Prior Year, in Penalty Period	9,202	80.6
AMI Performance in Prior Year, in Penalty Period, Conditional on Receiving a Penalty on Any of the Measures in Prior Year	5,740	62.4
	Mean	
Disproportionate Share Hospital (DSH) Percent	26.5	
Prior FY Payment Adjustment Factor, in Penalty Period	0.996	
Prior FY AMI Excess Readmissions Ratio Minus 1, in Penalty Period	0.035	
Medicare Percentage of Inpatient Days	43.7	

Notes: This table presents key patient and hospital characteristics for the study population that returned to *any* hospital within 30 days by ambulance (n=24,823).

As noted above, for the analyses *conditional on returning to any hospital*, a *second study population* was formed by restricting the first study population to beneficiaries who returned to *any* hospital within 30 days by ambulance. Specifically, the second study population reflects patients who had a revisit to *any* hospital (that consistently met the minimum case requirements to receive an HRRP measure score) within 30 days by ambulance (regardless of whether they were readmitted). This produced a national sample of 24,823 beneficiaries. Table 2.1 presents patient characteristics of this *second study population* as well as hospital characteristics for the hospitals to which these patients returned within 30 days by ambulance.

2.4.2 Effects of the HRRP on the Probability of a Revisit to Any Hospital Within 30 Days

For the first study population, Table 2.2 presents the probability of returning to *any* hospital within 30 days (regardless of mode of transportation or readmission) results. It shows the extent to which there is heterogeneity, by safety-net status and race/ethnicity. As discussed in the [1st dissertation paper], overall, across all hospitals, the probability of the given patient returning to *any* hospital within 30 days decreased by 0.3 percentage points, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure. As providers face larger incentives to improve on the HRRP AMI measure, the probability of their patients returning to any hospital decreases.

There is some evidence of heterogeneity in provider responsiveness to the underlying incentives. Table 2.2 shows differences by patient race within all hospitals (top panel) and for safety-net hospitals compared to non-safety-net hospitals (bottom panel). Across all hospitals, Non-White patients were more likely than White patients to return to any hospital within 30 days. Specifically, before HRRP implementation, Non-White patients were 1.6 percentage points more likely than White patients to return to any hospital within 30 days (regardless of whether

they were readmitted). In contrast, patients discharged from *safety-net* hospitals (see *Data Sources, Study Population, and Measures* section for definition), compared to patients discharged from *non-safety-net* hospitals, were *not* more likely to return to any hospital within 30 days. On average, these racial differences within all hospitals persisted under the HRRP.

Table 2.2: Heterogeneity by Race/Ethnicity and Safety-Net Status in the Probability of Revisit to Any Hospital Within 30 Days (Regardless of Readmission)

Return to Any Hospital Within 30 Days (Regardless of Readmission), *For Full HRRP AMI Study Population*	Coefficient (Marginal Incentive Interaction Multiplied by 0.0005 Average Scaled Marginal Incentive)	
Overall Responsiveness to Increases in Marginal Incentive	-0.3	*
Within All Hospitals By Race/Ethnicity		
Non-White Patient Main Effect	1.6	***
Non-White Patient Interaction With Post-Period	-0.8	
Non-White Patient Interaction With Post-Period and Marginal Incentive	-0.4	
Safety-Net Hospitals Compared to Non-Safety-Net Hospitals		
Safety-Net Hospital Main Effect	0.4	
Safety-Net Hospital Interaction With Post-Period	0.6	
Safety-Net Hospital Interaction With Post-Period and Marginal Incentive	-0.2	

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 0.0005 average non-zero scaled marginal incentive, for the marginal incentive interaction) from the probability of revisit to *any* hospital within 30 days results. This reflects the change in the *percentage points of probability* of returning to *any* hospital within 30 days, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure (due to a one-decile change in the AMI Excess Readmissions Ratio). The study population for these analyses reflects beneficiaries with a 2009-2017 discharge from an AMI HRRP index admission.

Table 2.3: Heterogeneity by Race/Ethnicity and Safety-Net Status in the Probability of Revisit to Any Hospital Within 30 Days (Regardless of Readmission)

Return to Any Hospital Within 30 Days (Regardless of Readmission), *For Full HRRP AMI Study Population*	Coefficient (Marginal Incentive Interaction Multiplied by 0.0005 Average Scaled Marginal Incentive)	
Within Safety-Net Hospitals By Race/Ethnicity		
Non-White Patient Main Effect	1.2	
Non-White Patient Interaction With Post-Period	-0.2	
Non-White Patient Interaction With Post-Period and Marginal Incentive	-0.7	
Within Non-Safety-Net Hospitals By Race/Ethnicity		
Non-White Patient Main Effect	2.2	***
Non-White Patient Interaction With Post-Period	-1.7	*
Non-White Patient Interaction With Post-Period and Marginal Incentive	-0.2	

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 0.0005 average non-zero scaled marginal incentive, for the marginal incentive interaction) from the probability of revisit to *any* hospital within 30 days results. This reflects the change in the *percentage points of probability* of returning to *any* hospital within 30 days, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure (due to a one-decile change in the AMI Excess Readmissions Ratio). The study population for these analyses reflects beneficiaries with a 2009-2017 discharge from an AMI HRRP index admission.

Table 2.3 decomposes the racial disparity found across all hospitals on average into any racial disparities by safety-net hospital status. Among *non-safety-net* hospitals (bottom panel of Table 2.3), there was also a racial disparity in the probability of patients returning to any hospital within 30 days before HRRP implementation. However, this racial disparity *narrowed* in the

post-HRRP implementation period. Specifically, among all *non-safety-net* hospitals in the pre-period, minority patients were 2.2 percentage points more likely than non-minority patients to return to any hospital within 30 days (regardless of whether they were readmitted). In the post-period, this difference decreased by 1.7 percentage points. That said, there was *no* difference in how hospitals respond by patient race with increases in the hospital-specific marginal incentive.

2.4.3 Effects of the HRRP on Hospital Readmission Decisions, Conditional on a Revisit to Any Hospital Within 30 Days

Table 2.4 presents the instrumental variable results of the differential change in the percentage points of probability of readmission, with increases in the scaled marginal incentive for index hospital visits compared to non-index hospital visits, post-HRRP implementation.

Table 2.4: Heterogeneity by Race/Ethnicity and Safety-Net Status in the Instrumental Variables Results

Any Readmission, *For HRRP AMI Study Population That Returned to Any Hospital Within 30 Days by Ambulance (Regardless of Whether Readmitted)*	Coefficient (Marginal Incentive Multiplied by 0.0005 Average Scaled Marginal Incentive)	
Overall Responsiveness to Increases in Marginal Incentive	-6.8	*
Within All Hospitals By Race/Ethnicity		
Non-White Patient Interaction With Index Visit, Post-Period, and Marginal Incentive	4.8	
Safety-Net Hospitals Compared to Non-Safety-Net Hospitals		
Safety-Net Hospital Interaction With Index Visit, Post-Period, and Marginal Incentive	-6.4	

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 0.0005 average non-zero scaled marginal incentive, for the marginal incentive interaction) from the instrumental variable results of the differential change in percentage points of probability of the outcome variable, with increases in the scaled marginal incentive for improvement on the HRRP AMI measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. The results reflect care decisions by the hospital to which the given beneficiary returned, conditional on the AMI HRRP beneficiary returning to *any* hospital within 30 days (regardless of readmission). The study population for each of these analyses reflects the AMI HRRP beneficiaries who return to *any* hospital (regardless of readmission) by ambulance within 30 days of a 2009-2017 discharge from an AMI HRRP index admission.

Overall, as discussed in [dissertation paper 1], there was a differential decrease in the probability of readmitting the given patient, with increases in the hospital-specific scaled marginal incentive for improvement on the hospital's reported HRRP AMI Measure (due to a one-decile change in the AMI Excess Readmissions Ratio), for index hospital visits compared to non-index hospital visits, post-HRRP implementation. However, this hospital responsiveness to the underlying incentives did not differ within all hospitals by patient race or for safety-net hospitals compared to non-safety-net hospitals.

2.5 Discussion

This research has numerous implications that arise from the empirical findings. First, there was *within-hospital* heterogeneity by patient race in the probability of returning to any hospital. Prior to HRRP implementation, Non-White patients were more likely than White patients *within* the given hospital to return to a hospital within 30 days. These *within-hospital* differences on average across all hospitals persisted with HRRP implementation. However, the *safety-net* status of these hospitals may play a role in whether there were significant within-hospital racial disparities preceding HRRP implementation as well as how these changed with HRRP implementation. Among hospitals characterized as *non-safety-net* over this time period, Non-White patients were indeed more likely than White patients *within* the given hospital to return to a hospital within 30 days. Yet, this within-hospital difference narrowed following HRRP implementation. This may be due to allocating limited resources to trying to prevent hospital revisits among patients perceived to be at highest risk, such as minority patients. To the extent that this has been achieved through positive changes, such as improved discharge processes and follow-up, this narrowing disparity may signal improved patient outcomes and

care delivery. Responsiveness in reducing this racial disparity post-HRRP implementation did *not* appear to increase with increases in the marginal incentive to improve. In contrast, among hospitals characterized as *safety-net* over this time period, there was *no* evidence of a *within-hospital* racial disparity among the study population before or after HRRP implementation. This may because patients within *safety-net* hospitals reflect more vulnerable patients across the board.

Second, *conditional on returning to any hospital in 30 days*, where hospital choice is effectively randomized by ambulances, there was *no* evidence of differential treatment by race or safety-net status with increases in the incentive to improve on the readmissions measure. Because this approach focuses on patients *who have already returned to any hospital by ambulance*, it reflects a more homogeneous patient population and addresses patient selection of hospitals. Consequently, it may seem reasonable that there is *no* advantage to focusing efforts on decreasing readmissions *for this patient population at this stage by patient race*. Decreasing readmissions at this stage involves shifting to treatment through the ED. As a result, this involves a different process than upfront efforts aimed at predicting patient risk of returning to a hospital within 30 days and allocating resources to trying to prevent hospital revisits (regardless of readmission). If differences were found for this patient population at this stage by patient race, this might present concerns depending on how this was achieved. As previously noted, if hospitals disproportionately decrease the probability of readmitting Non-White patients, conditional on patients returning to a hospital, this could potentially have negative effects for the patient. This could potentially forgo needed care or subject the patients to more financial liability.

This study is limited to one HRRP condition and to patients who return to the hospital by ambulance for the analyses of patients returning to any hospital. Consequently, this is not the full set of HRRP conditions and procedures, so it is not the full picture of how the HRRP affects disparities across all patients. There may be additional heterogeneity in treatment effects by patient race or safety-net status across other conditions and patient populations. However, this study estimates the causal effect of HRRP incentives and addresses patient selection of hospitals, and to the extent that the study population reflects the most serious cases, this then reflects conservative estimates. While this research focuses on the Medicare FFS population, this is exactly the population targeted by the HRRP. Additionally, given the scope of the study populations, there can be sample size limitations to investigate other changes.

Third, this research builds on prior research and addresses gaps. As noted, this research is the first to exploit *exogenous variation* in hospital incentives to obtain *causal estimates* of the effects of readmission incentive design on disparities. There is variation in treatment of *index* versus *non-index* hospital visits from before to after the HRRP, along with variation in the magnitude of the hospital-specific marginal incentive. This research also addresses patient selection of hospitals, so any resulting disparities reflect differences in how hospitals treat the given patients rather than differences in how patients select hospitals. This research builds on prior research. Some prior research has focused on the post-HRRP penalty period. This research focuses on the full HRRP implementation period. As previously noted, although penalties began FY2013, penalties were calculated based on prior performance, so hospitals had an incentive to react immediately to the 2011 announcement. Additionally, prior research has focused on readmissions overall, without differentiation based on underlying incentives (e.g., index vs non-index hospital visit, hospital-specific marginal incentive) for the given patient. Moreover, this

research decomposes readmissions into: analyses of the probability of hospital revisit (regardless of readmission or mode of transportation) and analyses of the probability of readmission, conditional on returning to a hospital within 30 days. This is beneficial to delve into this at each stage, since heterogeneity in treatment effects could vary at each stage, along with what this means for patient outcomes. Future research can build on this by investigating heterogeneity in treatment effects across other HRRP conditions and other patient populations. Additionally, future qualitative research could be conducted to further investigate the source of disparities in readmission rates and the extent to which this is perceived as a concern to address by patients and providers.

Fourth, this research emphasizes the potential for policy refinement to improve societal outcomes. Because Non-White patients were more likely than White patients within the given hospital, across all hospitals on average, to return to a hospital within 30 days, the HRRP could be refined to more explicitly incentivize and reward reducing revisits to any hospital within 30 days (regardless of readmission). After all, curtailing revisits that would have resulted in emergency department care (but not readmissions) at *index* hospitals with a *positive* marginal incentive or that would have resulted in *any* care at *index* hospitals with *zero* marginal incentive sacrifices the given index hospital's revenue without producing rewards. Instead, more explicitly rewarding reducing revisits could incentivize investments in effort to curtail revisits and, in turn, readmissions across hospitals. This is particularly imperative because investments in effort to curtail readmissions can be costly in terms of time and resources, limiting the capacity of hospitals with lower resources to implement such changes. Additionally, separately reporting and calculating performance on (1) revisits to any hospital, (2) readmissions at index hospitals, and (3) readmissions at non-index hospitals would reduce distortions in the current overall

readmission measure and provide clarity on performance that the index hospital has more control over. Moreover, if *all index and non-index hospitals* were subject to at least *some* incentive to curtail readmissions, this would (1) diminish distortion in reported performance, (2) reduce penalties based on decisions outside the index hospital's direct control, and (3) further incentivize and reward efforts to curtail readmissions. These changes in turn could lead to imperative improvements in readmission reductions, quality, and patient safety across hospitals.

2.6 Chapter 2 Bibliography

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Chapter 3: Are There Changes in Provider Surgical Practices Following Changes in Hospital Financial Incentives?

3.1 Introduction

Hysterectomies are a widespread procedure. With approximately 600,000 performed annually, hysterectomies are the second most common surgical procedure for women (Lindgren, 2016). Historically, there have been several key differences between the ways that hysterectomies can be performed in terms of financial and patient recovery outcomes. Compared with other hysterectomy types (e.g., vaginal hysterectomies), abdominal hysterectomies have worse patient outcomes as well as higher health care spending. Indeed, the American Congress of Obstetricians and Gynecologists reports that a vaginal hysterectomy generally causes fewer complications than abdominal hysterectomy, and it recommends vaginal hysterectomy as the first choice for hysterectomy (ACOG). Hysterectomy complications, across the different procedure types, can be significant and include wound infection, bleeding, blood clots, and nerve and tissue damage (ACOG). Abdominal hysterectomies are also the most invasive and least cost-effective way to remove a uterus for non-cancerous reasons (Lindgren, 2016; Warren, Ladapo, Borah, Gunnarsson, 2009). Prior research has also found that abdominal hysterectomy types are "associated with [more] infectious morbidity, [longer] hospital stay, and [slower] return to normal activity" than non-abdominal hysterectomy types. (Contemporary OB/GYN., 2013; Nieboer, Johnson, Lethaby, et al., 2009; Walsh, Walsh, Tang, Slack, 2009; Brezina, Beste, Nelson, 2009; Garry, Fountain, Mason, et al., 2004; Miskry, Magos, 2003; Seracchioli,

Venturoli, Vianello, et al., 2002; Hwang, Seow, Tsai, et al., 2002; Ottosen, Lingman, Ottosen, 2000; Falcone, Paraiso, Mascha, 1999; Marana, Busacca, Zupi, et al., 1999).

Despite these superior patient outcomes from a non-abdominal hysterectomy, choice of procedure has also been found to be a function of *non-medical* considerations, including procedure reimbursement; surgeon training and experience; average case volume; available hospital technology, devices, and support; and preference of the informed patient (ACOG, 2017). Moreover, the American College of Obstetricians and Gynecologists says historically the "low rate of vaginal hysterectomies is because too few practicing gynecologists have been trained in the technique, and those who have been trained don't perform them often enough to be comfortable with the procedure." (Lindgren, 2016).

Estimates from FAIR Health (which are based on claims for medical services paid for by private insurance plans) shed light on the considerable reimbursement differences between distinct hysterectomy procedure types for *non-Medicare* patients (FAIR Health). Specifically, the 80th percentile in-network reimbursement in one large city is $9,644 for the CPT code corresponding to vaginal removal of the uterus (when the uterus weighs 250 grams or less, which exceeds the average uterus weight of 50 grams). In contrast, the 80th percentile in-network reimbursement in the same city is roughly twice as high at $18,794 for the CPT code corresponding to abdominal removal of the uterus. These estimates not only include reimbursement for the primary medical procedure but also reimbursement for related costs, such as anesthesia and hospital outpatient facility estimates. Consequently, such estimates are more comprehensive than those that omit related costs or estimates that only report the patient cost-sharing of total reimbursement. In contrast to this wide variation in reimbursement by type of hysterectomy procedure (e.g., abdominal hysterectomy) for non-Medicare patients, DRG

payments used to reimburse providers for performing hysterectomies for the *Medicare* population do not differentiate between type of hysterectomy performed. However, Medicare is the secondary payer for patients aged 65 or older who also have coverage through an employer group health plan (unless the employer has fewer than 20 employees, in which case Medicare is the primary payer) (CMS, 2023).

Since then, the Hospital-Acquired Condition Reduction Program (HACRP) and Hospital Value-Based Purchasing (HVBP) Program were created to incentivize hospital improvement on reported performance measures through financial incentives. Beginning FY 2016, both the HACRP and the HVBP Program have incorporated a surgical site infection (SSI) following *abdominal hysterectomy* measure into the set of measures for which hospitals are rewarded or penalized. One particularly important thing to note is that while bonuses or penalties are applied strictly to *Medicare* reimbursement, abdominal hysterectomy measure performance is calculated based on hospital performance following abdominal hysterectomies for all patients ages 18 and older (*regardless of their insurance coverage*). Because this measure does *not* include hospital performance following *non-abdominal* hysterectomies, the incentives to select specific hysterectomy procedures have changed.

Yet the effects of these financial incentives on hysterectomy procedure choice and resulting patient, hospital, and Medicare outcomes remain unknown. This research addresses these knowledge gaps. Specifically, this research investigates whether changes in financial incentives to improve abdominal hysterectomy-based measure performance under the HACRP and the HVBP Program influence type of hysterectomy as well as subsequent care and price-standardized spending outcomes for hysterectomy patients. The results inform deliberation of changes to reported hysterectomy performance, hospital practices, and policy design.

3.2 Conceptual Framework

Pay-for-performance programs intend to improve care through financial incentives. The Hospital-Acquired Condition Reduction Program (HACRP) and Hospital Value-Based Purchasing (HVBP) Program are mandatory programs created by the Affordable Care Act to provide financial incentives to improve performance for targeted conditions or procedures. Beginning FY 2016, both the HACRP and the HVBP Program have incorporated a surgical site infection (SSI) following *abdominal hysterectomy* (even among non-Medicare patients) measure into the set of measures for which hospitals are rewarded or penalized. Yet, because the hysterectomy-based measure is calculated based only on performance on *abdominal hysterectomy*, but *not* other types of hysterectomies, this changes the marginal incentives to select a given hysterectomy approach across patients. In particular, providers face incentives to select other options (vaginal hysterectomy), overall or in perceived higher-risk cases, to completely avoid risk of a negative hysterectomy outcome leading to worse reported performance and penalties. Both the HACRP and the HVBP Program adjust payments applied to all Medicare fee-for-service (FFS) base operating diagnosis-related group (DRG) payments for hospitals based on their performance on the targeted measures. Under the HACRP, CMS penalizes hospitals 1% of their inpatient revenue if they fall in the worst-performing quartile of hospitals with respect to performance on hospital-acquired conditions. Under the HVBP program (Norton, Li, Das, Chen, 2018; Norton, Lawton, Li, 2023), hospitals are eligible to receive a penalty or bonus based on their total performance score, which is calculated based on their performance across all measures for which they receive a score. Overall, at least 17 percent of a hospital's total HACRP score is based on its hysterectomy-based measure performance.

Additionally, for some hospitals, such as those missing scores for other measures, hysterectomy-based measure performance has an even greater outsized effect on overall performance. Moreover, because this hysterectomy-based measure is also included under the HVBP Program, this further increases its overall importance.

With changes in financial incentives for hospitals to improve on hysterectomy performance, it is critical to better understand how hospitals are responding as a function of these financial incentives and how hysterectomy patients fare in terms of subsequent hospital care and price-standardized spending as a result of these incentives. Hospital reimbursement ultimately consists of both direct and indirect marginal reimbursement, generating both direct and indirect financial incentives for providers to select specific procedure options. Indirect marginal reimbursement reflects changes in penalties or bonuses based on changes in performance on pay-for-performance measures. Over the study period, the direct marginal reimbursement by payer remained consistent for providers, but providers experienced changes in the indirect marginal financial incentive to select a particular type of hysterectomy. For a given measure, this indirect marginal incentive varies across hospitals, from zero at the margin to considerably large financial incentives. This is based on which measures comprise the final set of measures for which a given hospital qualifies to receive a score, the hospital's performance relative to other hospitals across those measures, its performance relative to its prior performance on the given measure (in the case of the HVBP Program), as well as its share of Medicare inpatient days. The fewer measures for which a hospital qualifies, the more outsized contribution a given measure has towards that hospital's performance. The higher the hospital's Medicare percentage of inpatient days, the more reimbursement is at stake for the hospital due to changes in its performance.

Hospitals may respond to increases in incentives to improve hysterectomy performance by shifting to non-included procedure types, particularly in light of imperfect risk adjustment. Although the HACRP and HVBP Program try to account for patient risk in determining hospital performance, risk adjustment for calculating performance is far from perfect in critical ways (Lawton, Sheetz, Ryan, 2020). This further increases incentives for providers to respond in alternative ways that improve reported performance, such as shifting towards non-included procedure types to avoid risk of penalty. In particular, the current risk methodology is insufficient to address the large heterogeneity across patients and hospitals. Compared with other programs, HACRP and HVBP Program measures incorporate wide-ranging diagnoses, increasing heterogeneity in patient characteristics across hospitals. Hospitals performing more surgery face increased risk for additional hospital-acquired conditions, as surgical patients are eligible for more HACRP measures. Additionally, certain measures omit key patient characteristics that increase risk of the hospital-acquired condition. For example, surgical site infection risk adjustment neglects (1) preoperative diagnosis, (2) whether the case is elective or emergent, and (3) patient immunosuppression — despite the effect of these variables on risk and their variation across hospitals. Risk adjustment is limited to just a few variables for the abdominal hysterectomy-based measure, and prior research found that over half of hospitals' ranking position would change under risk adjustment models that include additional variables, which would change their HACRP measure scores (Morgan, Kamdar, Regenbogen, Krapohl, Swenson, Pearlman, Campbell, Hendren, 2018). Because patient comorbidities can affect hysterectomy decisions and resulting outcomes, overall and in light of limited risk adjustment for determining hospital performance, this research controls for patient comorbidities in all analyses.

This research tests whether changes in hospital financial incentives influence health care supply and resulting patient outcomes, in the context of hysterectomy practices and pay-for-performance programs. Specifically, it investigates whether there was a decrease in the probability of performing abdominal hysterectomies, as well as a decrease in subsequent hospital care and price-standardized spending for hysterectomy patients, from before to after implementation of hysterectomy-related hospital financial incentives under the HACRP and HVBP programs, and whether this effect increased with the hospital-specific marginal incentive for improvement. This research not only exploits variation in incentives from before to after HACRP and HVBP Program implementation, but it also exploits variation in the magnitude of the hospital-specific marginal incentive. Additionally, all analyses control for patient demographic and severity variables, hospital characteristics, patient insurance type which reflects differences in direct financial marginal incentive for the given procedures, as well as quarter-year. This study sheds light on the role of financial incentives for a commonly performed surgery with large capacity for substitution among procedure types, but nevertheless previously low rates of performing certain types for which there is evidence of more favorable outcomes. Investigating changes in provider surgical practices and resulting patient outcomes following changing financial incentives informs the way we think about hospital comparisons pertaining to hysterectomy performance and the design of pay-for-performance incentives.

3.3 Methods

3.3.1 Analytic Approach

This research investigates whether changes in hospital financial incentives influence health care supply and resulting critical outcomes, in the context of hysterectomy practices and

the HACRP and HVBP pay-for-performance programs. First, this study calculates the hospital-specific marginal incentive (Norton et al., 2018; Norton, Lawton, Li, 2023) for improvement on the given hysterectomy-based measure for each hospital and time period. The hospital-specific marginal incentive for each condition measures how much an improvement in the condition-specific readmission would affect performance, and subsequently Medicare reimbursement. Since hospitals vary in their percentage of patients covered by Medicare, hospitals that are more dependent on Medicare revenue may be more responsive to financial incentives affecting all Medicare fee-for-service (FFS) base operating diagnosis-related group (DRG) payments. To account for this, the hospital-specific marginal incentive to improve is subsequently scaled by the hospital's Medicare percentage of inpatient days in the given time period in all models.

This study then investigates whether the probability of performing an abdominal hysterectomy changed as a function of the hospital-specific marginal incentive for improvement on the hysterectomy-based measure following its implementation. The hypothesis is that the coefficient sign will be negative, indicating that the probability of performing an abdominal hysterectomy decreases as the hospital's marginal incentive for improvement increases. Consequently, as providers face stronger incentives, they may seek to improve reported performance on this measure through selecting less risky patients for this procedure or substituting towards non-included hysterectomy procedures across patients more generally. This would help providers avoid risk of an adverse outcome counting against the hospital.

Additionally, this research investigates whether the probability of hysterectomy patients receiving subsequent care in the hospital changed as a function of the hospital-specific marginal incentive for improvement on the hysterectomy-based measure. Specifically, it investigates changes in the probability of receiving care through the emergency department or being

readmitted in the 90 days following the hysterectomy. Because there is greater risk of adverse outcomes following *abdominal* hysterectomies, the hypothesis is that this coefficient sign will be negative. This indicates that, as financial incentives increase (incentivizing reductions in the probability of an abdominal hysterectomy), the probability of subsequent hospital care then decreases.

Furthermore, this research investigates whether post-hysterectomy price-standardized spending changed as a function of the hospital-specific marginal incentive for improvement on the hysterectomy-based measure. To this end, this research investigates changes in the probability of any post-hysterectomy price-standardized spending as well as changes in the amount of post-hysterectomy price-standardized spending, overall and conditional on having any post-hysterectomy price-standardized spending. Analogous to the subsequent hospital care models, because there is greater risk of adverse outcomes following abdominal hysterectomies, the hypothesis is that the coefficient sign will be negative for each outcome.

This research conducts difference-in-differences analyses, with separate sets of difference-in-differences terms for the HACRP and for the HVBP Program. Since either the HACRP or the HVBP Program could have a stronger effect on study outcomes, the analyses include the effect of each program, while controlling for the effect of the other program. Because the hysterectomy-based measure was added to both programs in FY 2016 for all applicable hospitals, there was *not* a staggered start. Additionally, the parallel trends in the pre-period assumption cannot be tested. For the difference-in-differences terms for each program, the post-period reflects post-implementation of the hysterectomy-based measure, while the treatment reflects a dose-effect of the magnitude of the hospital-specific marginal incentive for improvement on the given hysterectomy-based measure.

There are three sets of outcomes. The first reflects the probability of performing an abdominal hysterectomy, conditional on performing any hysterectomy. Second, to evaluate how differing financial incentives pertaining to hysterectomy performance affect subsequent hospital care, the outcome measures include the probability of receiving care through the emergency department or being readmitted in the 90 days following the hysterectomy. Specifically, the outcome measures reflect the probability of a readmission in 30 days, any emergency department care or any readmission in 90 days, any emergency department care in 90 days (regardless of readmission), any readmission in 90 days (regardless of emergency department care), emergency department care but no readmission in 90 days, emergency department care and readmission in 90 days, readmission but no emergency department care in 90 days**.** Third, to evaluate how differing financial incentives pertaining to hysterectomy performance affect post-hysterectomy price-standardized spending, the outcome measures include the probability of any post-hysterectomy price-standardized spending, the amount of post-hysterectomy price-standardized spending overall, and the amount of post-hysterectomy price-standardized spending conditional on having any post-hysterectomy price-standardized spending. To focus on differences in utilization of care, instead of differences in price from negotiated payment rates, this research price-standardizes payments using algorithms developed by the Dartmouth Atlas of Health Care (Gottlieb, Zhou, Song, Andrews, Skinner, Sutherland, 2010) and used in prior work (Regenbogen, Cain-Nielsen, Syrjamaki, Chen, Norton, 2019; Miller, Gust, Dimick, Birkmeyer, Skinner, Birkmeyer, 2011; Birkmeyer, Gust, Baser, Dimick, Sutherland, Skinner, 2010).

For each outcome of interest *Y*, this research uses the following main model at the patient level for patient *i*, hospital *j*, and quarter-year *t*. The main explanatory variables capture the hospital-specific marginal incentive for improvement on the hysterectomy-based measures in the

HACRP and HVBP pay-for-performance programs, respectively, in the post-implementation time period. This time period is after FY 2016, when hospitals started to be rewarded or penalized based on a set of measures that includes the abdominal hysterectomy-based measure. Additionally, all analyses control for patient demographic and severity variables, the direct financial marginal incentive, hospital characteristics, as well as quarter-year and hospital effects. For all analyses, cluster-robust standard errors are estimated to account for repeated observations within hospitals.

The following reflects the main regression model at the patient level for patient *i*, hospital *j*, and time-period *t* for patients who received a hysterectomy (Equation 1).

$$
\begin{aligned}
(4)\ Y_{i,j,t} = {} & \beta_0 + \beta_1 HACRP_HospMarginalIncentive_{j,t} + \beta_2 Post_t \\
& + \beta_3 HACRP_HospMarginalIncentive_{j,t} \times Post_t \\
& + \beta_4 HVBP_HospMarginalIncentive_{j,t} \\
& + \beta_5 HVBP_HospMarginalIncentive_{j,t} \times Post_t \\
& + \beta_6 DifferenceDirectReimbursement_{j,t} \\
& + \beta_7 X_{i,t} + \beta_8 H_j + \beta_9 (Quarter\text{-}Year_t) + \beta_{10} \lambda_j + \varepsilon_{i,j,t}
\end{aligned}
$$

where $HACRP_HospMarginalIncentive_{j,t}$ is the hospital-specific marginal incentive for improvement on the hysterectomy measure under the HACRP, $HVBP_HospMarginalIncentive_{j,t}$ is the hospital-specific marginal incentive for improvement on the hysterectomy measure under the HVBP Program, $Post_t$ is whether the time period was after HACRP/HVBP Program implementation of the hysterectomy measures, $DifferenceDirectReimbursement_{j,t}$ reflects payer source indicator variables, thereby capturing the effect of differences in the direct financial marginal incentive, $Quarter\text{-}Year_t$ reflects a set of dummy variables for the time period that the visit occurred, $X_{i,t}$ is a vector of patient characteristics (age, race, dual eligibility, severity (based

on Hierarchical Condition Category and Elixhauser Comorbidity Index approaches), primary diagnosis), H_j is a vector of hospital characteristics (such as size, Disproportionate Share Hospital (DSH) percent, teaching affiliation, and for-profit status), λ_j reflects hospital effects, and $\varepsilon_{i,j,t}$ is an error term.

The first coefficient of interest is the coefficient on the *HACRP* hospital-specific marginal incentive and post-period interaction term (β_3), which captures whether the outcome changed with changes in the marginal incentive to improve on the *HACRP* hysterectomy-based measure following its implementation. The second coefficient of interest is the coefficient on the *HVBP Program* hospital-specific marginal incentive and post-period interaction term (β_5), which captures whether the outcome changed with changes in the marginal incentive to improve on the *HVBP Program* hysterectomy-based measure following its implementation. The current specification assumes a constant effect in each year. However, it may be that the effect varies over time rather than reflect homogeneous effects by year. Consequently, this research will subsequently test for heterogeneous effects by year. For each main outcome, the hypothesized treatment effect sign is negative. It is also hypothesized that the treatment effect will be stronger as the hospital-specific marginal incentive increases.

3.3.2 Data Sources and Study Population

To investigate whether, in the context of hysterectomy practices and the HACRP and HVBP pay-for-performance programs, changes in hospital financial incentives influence health care supply and resulting patient outcomes, this research needs data on hysterectomy patients. This includes data pertaining to patient diagnosis and type of hysterectomy performed. This research also needs information on whether the hospital qualifies for the hysterectomy-based

measure in the HACRP and HVBP Program; the type of payer which reflects the direct financial marginal incentive for each procedure; provider readmission and care through the emergency department decisions; patient demographics; co-morbid conditions; as well as timing and location of visits and stays. Additionally, for every hospital, this research needs data on hospital characteristics, HACRP and HVBP Program performance, and previous payment adjustments resulting from these pay-for-performance programs to control for these factors in the analyses.

For all analyses, this research uses Michigan Value Collaborative (MVC) data. MVC reflects a partnership between Michigan hospitals, physician organizations, and Blue Cross Blue Shield of Michigan/Blue Care Network and aims to improve quality through rigorous performance feedback, empirical identification of best practices, and collaborative learning. Although MVC data are limited to Michigan, the data reflect Blue Cross Blue Shield of Michigan (BCBSM), Blue Care Network (BCN), and Medicare, so it captures multiple payers as well as adult patients younger than 65 (who are more likely to receive the procedure). Moreover, the data enable identification of specific hospitals, which is critical for calculating the hospital-specific marginal incentive for improvement on the hysterectomy measure under pay-for-performance programs. Claims data from these payers are then used to create episodes of care for different surgical and medical conditions that start with an index event, such as a hysterectomy, and include all claims within the 30- or 90-days following the procedure.

This research uses these data to identify patients for whom a hysterectomy was performed; the primary diagnosis; type of hysterectomy performed; type of payer thereby reflecting the direct financial marginal incentive for each procedure; provider readmission and care through the emergency department decisions; patient demographics; co-morbid conditions; as well as timing and location of visits and stays. To control for hospital characteristics such as

number of beds, Disproportionate Share Hospital (DSH) percent, Medicare share of inpatient days, teaching affiliation, and for-profit status, this research supplements the data with the Impact File and the American Hospital Association Annual Survey. To additionally incorporate hospital-specific incentives, this research uses lagged HACRP and HVBP Program performance data for each hospital and time frame. It also uses HACRP and HVBP Program performance data for each hospital and time frame to identify whether the hospital qualifies for the hysterectomy-based measure in the HACRP and HVBP Program.

The study population reflects beneficiaries (1) who received a 2015-2021 hysterectomy at a hospital that consistently met the criteria to receive a measure score for the hysterectomy-based measure under the HACRP and the HVBP Program and (2) who were commercially insured under either Blue Cross Blue Shield of Michigan (BCBSM) or Blue Care Network (BCN) or were enrolled in Medicare. Additionally, the probability of performing an abdominal hysterectomy analysis reflects beneficiaries in this study population for which information is available about whether an abdominal hysterectomy was performed.

3.4 Results

3.4.1 Beneficiary and Hospital Characteristics of the Two Study Populations

As noted above, for the probability of performing an abdominal hysterectomy analysis, the study population reflects the subset of hysterectomy patients for which information is available about whether an abdominal hysterectomy was performed (for the full description of the *two study populations*, see the above Study Population section). This produced a sample of 7,172 beneficiaries. For the remaining analyses, the study population reflects the broader study population. This produced a sample of 24,806 beneficiaries. Table 3.1 presents descriptive

statistics of the key outcome variables for the given study population over the full study time frame across hospitals.

Table 3.1: Descriptive Statistics Over Study Time Frame, Key Outcome Variables, Beneficiaries Who Had Hysterectomy in 2015-2021

Probability of Type of Hysterectomy Decision, Among Full Study Population With Information Available on Hysterectomy Type	***n***	***%***
Abdominal Hysterectomy	6,110	14.8
Other Hysterectomy Types	1,062	85.2
Probability of Subsequent Hospital Care, Among Full Study Population	***n***	***%***
Any Care in the Emergency Department or *Any* Readmission Within 90 Days	2,159	8.7
Probability of Given Subsequent Hospital Care, Among Full Study Population	***n***	***%***
Any Care in the Emergency Department Within 90 Days (Regardless of Observation Stay or Readmission Status)	1,641	6.6
A*ny* Readmission Within 90 Days (Regardless of ED Care or Observation Stay)	715	2.9
Probability of Given Spending, Among Full Study Population	***n***	***%***
Any Post-Procedure Price-Standardized Spending	8,332	33.6
Post-Procedure Price-Standardized Spending, Among Given Population	***Mean***	
Overall, Among Full Study Population	662	
Conditional on Any Post-Procedure Price-Standardized Spending, Among Full Study Population	1,970	

Note: The study population for these analyses reflects beneficiaries that received a 2015-2021 hysterectomy at a hospital that consistently met the criteria to receive a measure score for the hysterectomy-based measure (n=24,806). The probability of performing an abdominal hysterectomy analyses reflects beneficiaries in this study population for which information is available about whether an abdominal hysterectomy was performed (n=7,172).

Table 3.2: Key Patient and Hospital Characteristics Over Study Time Frame, Beneficiaries Who Had Hysterectomy in 2015-2021

		Population with Type of Hysterectomy Information		Full Population	
Key Patient Characteristics, Over Full Time Period		***n***	***%***	***n***	***%***
Gender					
Female		7,172	100.0	24,806	100.0
Male		0	0.0	0	0.0
Race					
White		4,226	58.9	14,325	57.8
Black		421	5.9	1,938	7.8
Hispanic		53	0.7	121	0.5
Other		184	2.6	673	2.7
Unknown		2,288	31.9	7,749	31.2
Payer					
Medicare		1,535	21.4	4,767	19.2
Blue Cross Blue Shield of Michigan (BCBSM)		3,942	55.0	14,508	58.5
Blue Care Network (BCN)		1,695	23.6	5,531	22.3
Dually Eligible for Medicaid					
Not dually eligible		6,807	94.9	23,450	94.5
Dually eligible		365	5.1	1,356	5.5
Mean HCC Score		0.013		0.017	
Median Index Length of Stay (in Days)		2.3		2.3	
Mean Age at End of Reference Year		54.5		52.9	
Key Hospital Characteristics, Over Full Time Period		***n***	***%***	***n***	***%***
Hospital Size					
<100 Beds		65	0.9	74	0.3
100-299 Beds		2,269	31.6	7,151	28.8
300+ Beds		4,838	67.5	17,581	70.9
Teaching Affiliation		6,450	89.9	22,896	92.3
For-Profit Hospital		260	3.6	878	3.5
Safety-Net Hospital		2,428	33.9	8,407	33.9
Received Penalty Based on Performance on Any of the Measures in Prior Year, in Penalty Period:	*HACRP*	1,771	29.5	6,552	30.9
	HVBP Program	2,643	44.1	8,741	41.2
		Mean		***Mean***	
Disproportionate Share Hospital (DSH) Percent		29.1		28.8	
Prior FY Payment Adjustment Factor, in Penalty Period		0.001		0.001	
Prior FY Hysterectomy-Based Measure Performance, in Penalty Period		2.6		2.4	
Medicare Percentage of Inpatient Days		37.7		37.7	

Note: The study population for these analyses reflects beneficiaries that received a 2015-2021 hysterectomy at a hospital that consistently met the criteria to receive a measure score for the hysterectomy-based measure (n=24,806). The probability of performing an abdominal hysterectomy analysis reflects beneficiaries in this study population for which information is available about whether an abdominal hysterectomy was performed (n=7,172).

Table 3.2 presents key patient characteristics of both study populations as well as key hospital characteristics for the hospitals at which the patients received a hysterectomy that consistently met the criteria to receive a measure score for the hysterectomy-based measure under the HACRP and the HVBP Program. Race information was missing for all BCN enrollees. To confirm that inclusion of race in the models did not significantly affect the estimates for the key explanatory variables, models with and without controlling for race were conducted for the subset of the sample with known race. Indeed, controlling for race did not significantly affect the estimates for the key explanatory variables. Consequently, the full population was included in the models and race was controlled for where known.

3.4.2 Effects of the HACRP and HVBP Program Incentives on the Probability of Performing an Abdominal Hysterectomy, Conditional on Performing any Hysterectomy

Hausman tests were conducted to determine if the null hypothesis that the preferred model is random effects could be rejected for the probability of performing an abdominal hysterectomy and the probability of receiving subsequent hospital care models. The results show that the null hypothesis could *not* be rejected, so random effects models were subsequently conducted for these models. Table 3.3 presents the probability of performing an abdominal hysterectomy, conditional on performing any hysterectomy, results. It shows that the probability of performing an abdominal hysterectomy decreased, with increases in the scaled marginal incentive for improvement on the HACRP hysterectomy-based measure. Specifically, for each increase of 0.015 scaled marginal incentive (corresponding to the 10th percentile scaled HACRP marginal incentive value), the probability of performing an abdominal hysterectomy decreased by 4.0 percentage points ($p<0.01$). As providers face larger incentives to improve on the HACRP hysterectomy-based measure, the probability of performing an *abdominal* hysterectomy (rather

than a *non-included* hysterectomy procedure) decreases. This is consistent with the conceptual framework and the study hypotheses for provider responsiveness to the underlying financial incentive design. In contrast, after controlling for the HACRP marginal incentive, any additional increase in the marginal incentive to improve on the HVBP Program hysterectomy-based measure did not lead to additional significant changes in health care supply.

Table 3.3: Probability of Performing an Abdominal Hysterectomy, Conditional on Performing any Hysterectomy

Outcome Measure, ***For Study Population with Information on Hysterectomy Type***	**HACRP Marginal Incentive Coefficient (Multiplied by 10th Percentile Scaled Marginal Incentive Value)**		**HVBP Program Marginal Incentive Coefficient (Multiplied by 10th Percentile Scaled Marginal Incentive Value)**
Abdominal Hysterectomy	-4.0	***	-0.3

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 10th percentile scaled marginal incentive) from the probability of performing an abdominal hysterectomy (conditional on performing any hyterectomy) results. This reflects the change in the percentage points of probability of performing an abdominal hysterectomy, with increases in the scaled marginal incentive for improvement on the hysterectomy-based measure (due to a one-decile change in the hysterectomy-based measure) in the HACRP and HVBP Program. The study population for these analyses reflects beneficiaries that received a 2015-2021 hysterectomy at a hospital that consistently met the criteria to receive a measure score for the hysterectomy-based measure and for which information is available about whether it was an abdominal hysterectomy.

3.4.3 Effects of the HACRP and HVBP Program Incentives on Subsequent Hospital Care

Table 3.4 presents the probability of receiving subsequent hospital care within 90 days following the hysterectomy. It shows that the probability of receiving subsequent care through the emergency department or being readmitted within 90 days decreased, with increases in the scaled marginal incentive for improvement on the HVBP Program hysterectomy-based measure. Specifically, for each increase of 0.092 scaled marginal incentive (corresponding to the 10th percentile scaled HVBP Program marginal incentive value), the probability of receiving

subsequent care through the emergency department or being readmitted within 90 days decreased by 1.60 percentage points (p<0.01). As providers face larger incentives to improve on the hysterectomy-based measure under pay-for-performance programs, the probability of adverse patient outcomes following the hysterectomy decreases. This may be due to providers shifting to non-included hysterectomy procedures, which carry less risk of adverse patient outcomes, as well as efforts to reduce risk of a post-procedure infection across all procedure types. This is consistent with the conceptual framework and the study hypotheses for provider responsiveness to the underlying financial incentive design. This change was predominantly driven by decreases in care provided through the emergency department. In contrast, after controlling for the HVBP Program marginal incentive, any additional increase in the marginal incentive to improve on the HACRP hysterectomy-based measure did not lead to additional significant changes in receipt of subsequent care through the emergency department or a readmission in 90 days.

Table 3.4: Probability of Receiving Any Emergency Department Care or Any Readmission in 90 Days Following Hysterectomy

Whether Mutually Exclusive Care Decision	**Outcome Measure**	**HACRP Marginal Incentive Coefficient (Multiplied by 10th Percentile Scaled Marginal Incentive Value)**	**HVBP Program Marginal Incentive Coefficient (Multiplied by 10th Percentile Scaled Marginal Incentive Value)**	
	Readmission in 30 Days	**0.12**	**-0.34**	
Any Subsequent Hospital Care	***Any* Emergency Department Care or *Any* Readmission in 90 Days**	**0.62**	**-1.60**	*******
Non-Mutually Exclusive Care Decisions	*Any* Emergency Department Care in 90 Days (Regardless of Readmission)	0.45	-1.24	**
	Any Readmission in 90 Days (Regardless of Emergency Department Care)	0.29	-0.53	*
Mutually Exclusive Care Decisions	Emergency Department Care, But *No* Readmission in 90 Days	0.33	-1.07	**
	Emergency Department Care *And* Readmission in 90 Days	-0.12	-0.18	
	Readmission, But *No* Emergency Department Care in 90 Days	0.17	-0.35	*

**p<.10, **p<.05, ***p<.01*

Note: These results report the coefficient (multiplied by the 10th percentile scaled marginal incentive) from the probability of subsequent hospital care after receiving a hyterectomy results. This reflects the change in the percentage points of probability of subsequent hospital care, with increases in the scaled marginal incentive for improvement on the hysterectomy-based measure (due to a one-decile change in the hysterectomy-based measure) in the HACRP and HVBP Program. The study population for these analyses reflects beneficiaries that received a 2015-2021 hysterectomy at a hospital that consistently met the criteria to receive a measure score for the hysterectomy-based measure.

3.4.4 Effects of the HACRP and HVBP Program Incentives on Price-Standardized Spending Following the Hysterectomy

Table 3.5 presents two-part post-procedure price-standardized model results (Belotti, Deb, Manning, Norton, 2015). The first part of the two-part model predicts whether the given patient had any price-standardized spending following the hysterectomy. The second part predicts the amount of post-hysterectomy price-standardized spending conditional on any such spending.

The top row presents the probability of post-hysterectomy price-standardized spending. It shows that the probability of any post-hysterectomy price-standardized spending decreased, with increases in the scaled marginal incentive for improvement on the HVBP Program hysterectomy-based measure. Specifically, for each increase of 0.092 scaled marginal incentive (corresponding to the 10th percentile scaled HVBP Program marginal incentive value), the probability of any post-hysterectomy price-standardized spending decreased by 2.5 percentage points ($p<0.05$). As providers face larger incentives to improve on the hysterectomy-based measure under pay-for-performance programs, the probability of subsequent spending following the hysterectomy decreases. As noted above, this may be due in part to providers shifting to hysterectomy procedures not included under pay-for-performance programs. In addition to carrying less risk of adverse patient outcomes, these non-included procedures also have a significantly shorter recovery period, creating less opportunity or need for subsequent spending. This also may be due to efforts to diminish risk of adverse patient outcomes, such as a post-procedure infection, across all procedure types. This is consistent with the conceptual framework and the study hypotheses. In contrast, after controlling for the HVBP Program marginal incentive, any additional increase in the marginal incentive to improve on the HACRP hysterectomy-based measure did not lead to

additional significant changes in the probability of post-hysterectomy price-standardized spending.

Table 3.5: Post-Procedure Price-Standardized Spending Results

Outcome Measure, ***For Full Study Population***	**HACRP Marginal Incentive Marginal Effect for Given Population (Multiplied by 10th Percentile Scaled Marginal Incentive Value)**	**HVBP Program Marginal Incentive Marginal Effect for Given Population (Multiplied by 10th Percentile Scaled Marginal Incentive Value)**	
Probability of Any Post-Procedure Price-Standardized Spending, Among Full Study Population (%)	-0.6	-2.5	**
Post-Procedure Price-Standardized Spending, Overall, Among Full Study Population ($)	-35	-112	**
Post-Procedure Price-Standardized Spending, Conditional on Any Post-Procedure Price-Standardized Spending, Among Full Study Population ($)	-75	-213	

**p<.10, **p<.05, ***p<.01*

Note: The top-row results report the marginal effects (multiplied by the 10th percentile scaled marginal incentive) from the probability of price-standardized spending after receiving a hyterectomy results. This reflects the change in the percentage points of probability of post-procedure price-standardized spending, with increases in the scaled marginal incentive for improvement on the hysterectomy-based measure (due to a one-decile change in the hysterectomy-based measure) in the HACRP and HVBP Program. The second and third row results report the marginal effects (multiplied by the 10th percentile scaled marginal incentive) from the price-standardized spending after receiving a hyterectomy results. This reflects the change in post-procedure price-standardized spending for the given population, with increases in the scaled marginal incentive for improvement on the hysterectomy-based measure (due to a one-decile change in the hysterectomy-based measure) in the HACRP and HVBP Program. The overall study population for these analyses reflects beneficiaries that received a 2015-2021 hysterectomy at a hospital that consistently met the criteria to receive a measure score for the hysterectomy-based measure.

The second and third rows present the post-hysterectomy price-standardized spending overall and conditional on any post-hysterectomy price-standardized spending, respectively. It shows that post-hysterectomy price-standardized spending decreased overall, with increases in the scaled marginal incentive for improvement on the HVBP Program hysterectomy-based measure. Specifically, for each increase of 0.092 scaled marginal incentive (corresponding to the 10th percentile scaled HVBP Program marginal incentive value), average post-hysterectomy price-standardized spending decreased by $112 ($p<0.05$). As providers face larger incentives to improve on the hysterectomy-based measure under pay-for-performance programs, subsequent

spending over all patients following the hysterectomy decreases. This is driven by decreases in the probability of any post-hysterectomy price-standardized spending, with increases in the financial incentives. In contrast, conditional on any post-hysterectomy price-standardized spending, the change in post-hysterectomy price-standardized spending was not statistically significant.

3.5 Discussion

This research has critical findings and numerous implications that arise from the empirical findings. First, this research shows that hospitals are responsive to financial incentives underlying the abdominal hysterectomy-based measure under the HACRP and HVBP Program. This is beneficial in that, compared to other hysterectomies, abdominal hysterectomies are more likely to have worse patient outcomes, higher spending, and a longer recovery time. Consequently, incentives to enhance outcomes for abdominal hysterectomies can best target efforts to improve patient outcomes and lower medical spending. This can be achieved through some combination of shifting to *non-included* procedures or improving outcomes for the *included* procedures. In contrast, the underlying incentives could also have negative implications. This could occur if efforts to prevent infections are *not* sufficiently undertaken for *non-included* hysterectomy procedure types, since adverse outcomes for the *non-included* procedure types do *not* count against the hospital.

Second, this research shows that, as the financial incentive to improve on the hysterectomy-based measure increases, hospitals are more likely to shift to non-included hysterectomy procedures. Furthermore, provider responsiveness to the underlying incentives has effects on subsequent hospital care and price-standardized spending. As the financial incentive to

improve on the hysterectomy-based measure increases, patients are less likely to receive care through the emergency department, be readmitted, or experience any post-hysterectomy price-standardized spending. This then leads to decreases in the overall average post-hysterectomy price-standardized spending, with increases in the financial incentive to improve on the hysterectomy-based measure. Together, this improves societal outcomes, leading to better patient recovery and safety as well as reducing medical spending. Regardless of whether this is achieved predominately through shifting to more optimal hysterectomy procedures or decreasing infection risk for the included hysterectomy procedure, the hysterectomy-based measure can promote positive changes in health care delivery. However, because post-hysterectomy price-standardized spending, *conditional on having any post-hysterectomy price-standardized spending*, did *not* change with increases in the financial incentives, this highlights the importance of preventing adverse outcomes across hysterectomy types in more fully improving patient outcomes and reducing spending across the full population.

Moreover, because this spending reflects price-standardized spending, it removes spending differences due to variations in price from negotiated payment rates. Consequently, total spending that reflects such price differences can be considerably larger. This is particularly the case since most hysterectomy patients are *not* Medicare eligible, so any such spending for non-Medicare and non-Medicaid patients is subject to higher negotiated payment rates.

Additionally, because the study population does *not* include Medicaid enrollees, this does not reflect the most vulnerable population, for whom improved patient outcomes resulting from hysterectomy-based incentives is even more vital.

Third, this research highlights the role for policy refinement to further improve societal outcomes. As noted, the financial incentives do *not* explicitly incentivize efforts to prevent

infections among patients who receive a non-included hysterectomy. This is because these infections do *not* negatively affect reported quality measures and penalties under these pay-for-performance programs. Moreover, even though post-surgery infections are associated with a significantly higher percentage of hospital readmissions (Chan and Nimaroff, 2022), such readmissions also do *not* increase risk of hospital penalties, since the primary diagnosis for a hysterectomy is *not* a targeted condition under the Hospital Readmissions Reduction Program (HRRP).

Yet because surgical site infections can also occur for non-included procedures and contribute to patient morbidity and mortality, it is critical to better track and incentivize reductions of such infections as well. Conditional on having any post-hysterectomy price-standardized spending, there was *no* statistically significant decrease in post-hysterectomy price-standardized spending, with increases in the financial incentive to improve on the hysterectomy-based measure. This suggests that when complications occur for either type of procedure, they can have a similar deleterious effect. Indeed, prior research found that regardless of procedure type, patients that had an SSI had a mean length of stay that was three to five times longer than that of patients without an SSI (Roy, Patkar, Daskiran, Levine, Hinoul, Nigam, 2014). Infections following either type of procedure can lead to higher spending, longer hospital stays, and greater antibiotic utilization. Prior research has also found that, on average, patients who suffered a post-hysterectomy surgical site infection experienced costs that were twice as high as those for patients without a surgical site infection (Chan and Nimaroff, 2022).

Yet, refining policy to incentivize efforts to decrease infections from *non-included* types should be done in a way that does *not* undermine incentives to substitute towards such *non-included* types. This is because, rather than undercutting patient quality to avert financial risk,

substituting towards non-included types produces better patient outcomes and lower spending. Consequently, incentivizing shifts towards such care is beneficial for patients, hospitals, and national health care spending. This is especially the case given that hysterectomies are the second most common surgical procedure for women. Indeed, policy could even be further refined to provide *some* financial incentive to shift towards non-included hysterectomy types among hospitals facing *zero* marginal incentive to improve on the hysterectomy-based measure.

It is also critical to incentivize patient education to mitigate infection risks and identify complications. This could further improve overall understanding of the prevalence of such complications. Prior research has found that twice as many SSIs following abdominal hysterectomy were recorded when patients completed post-discharge questionnaires and interviews to identify wound signs and symptoms, relative to the rate when based on routine surveillance relying on just hospital data (Reilly, Allardice, Bruce, Hill, McCoubrey, 2006). This also builds on prior research that discusses how reported SSI performance relies on busy hospitals to accurately report infections that will then be used to penalize them (Lawton, Sheetz, Ryan, 2020). More explicitly incentivizing patient education and complication detection could also facilitate early detection of complications. This could then enable early intervention and further decrease critical adverse outcomes.

Insights gained from this research inform how we conceptualize hospital comparisons pertaining to hysterectomy performance and design of pay-for-performance incentives. Together, this can lead to critical improvements in patient recovery, safety, and overall health care spending for the numerous patients undergoing hysterectomies each year.

3.6 Chapter 3 Bibliography

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