The Impact of Medicare-funded GME on Physician Training, the Healthcare Workforce, and Hospital Quality

Hailey Brace

Abstract

Medicare is the largest single program providing explicit support for graduate medical education (GME) in the United States, funding about 20% of all direct medical education (DGME) costs. However, Medicare also enforces a time-invariant, hospital-specific cap on the number of residents it supports per year. Despite the enormous public investment in graduate medical education, previous research has not addressed how Medicare's DGME funding caps affect the number of residents per hospital, the general healthcare workforce, or healthcare quality. Exploiting a policy stipulation from the Affordable Care and Patient Protection Act, this paper examines the effect of Medicare-funded DGME on 1) the supply of medical residents, physicians, and physician assistants at the county level and 2) the quality of healthcare provision at the hospital level. The results suggest that an increased DGME funding cap is correlated with an increase in the county-level number of residents, but with a two-year lag from the date of the cap increase. The number of primary care residents is significantly higher beginning three years after the initial cap increase, and the number of nurse practitioners shows a significant increase four years after the cap is raised. Within the first five years after a cap increase, no significant change was detected in the county-level supply of physicians. No significant change in quality was detected at the hospital level.

Introduction

Graduate medical education, or GME, "provides the clinical training required for a physician to be eligible for licensure and board certification to practice medicine independently in the United States" (United States Government Accountability Office 2018). Medicare is the largest single program providing explicit support for GME in the United States, funding about 20% of all direct medical education (DGME) costs. DGME costs include medical residents' stipends and benefits, teaching physicians' salaries, accreditation fees, educational space, and related overhead expenses.

It is the responsibility of the Center for Medicare and Medicaid Services (CMS) to interpret the laws passed by Congress regarding GME funding, and to write and enforce regulations for DGME. CMS does not, however, have an obligation to analyze GME outcomes or "support the development and maintenance of a rational cost-effective new physician workforce" (Sanner & Voorhees 2017). Despite the enormous public investment in graduate medical education, there is a lack of research investigating how DGME funding affects the number of medical residents, the general healthcare workforce, or healthcare quality.

This paper analyzes the effects DGME funding using Section 5503 of Affordable Care and Patient Protection Act, which redistributed 726 Medicare funding slots in 2011. Under Section 5503, some hospitals that initially qualified to receive a DGME cap increase received no additional slots because the Center for Medicare and Medicaid Services (CMS) "ran out" before reaching the lowest-priority eligible states. These hospitals (or the counties they reside in) serve as the control group for hospitals that did receive a DGME cap increase in a difference-in-differences analysis. An event-study approach addresses possible lags in the effect of the cap increase, estimating the difference-in-differences coefficient separately for each of the first four to five years after the implementation of Section 5503.

The results suggest that an increased DGME funding cap is correlated with an increase in the county-level number of residents, but with a two-year lag from the date of the cap increase. The number of primary care residents is significantly higher beginning three years after the initial cap increase, and the number of nurse practitioners shows a significant increase four years after the cap is raised. Within the first five years after a cap increase, no significant change was detected in the county-level supply of physicians. No significant change in quality was detected at the hospital level.

Institutional Background

Federal funding for graduate medical education began with the establishment of Medicare in 1965 (Rich et al 2002). Acknowledging the need to support medical education as well as patient care, and anticipating that the introduction of both Medicaid and Medicare would cause an increase in the demand for medical services, the Committee on Ways and Means declared that "until the community undertakes to bear such education cost in some other way, that a part of the net cost of such activities [graduate medical education] (including stipends of trainees, as well as compensation of teachers and other costs) should be borne to an appropriate extent by the hospital insurance program" (Rich et al 2002; Young & Coffman 1998). Quickly, Medicare became the largest single source of funding for GME in the United States (Young & Coffman 1998).

In 1972, in an effort to slow the growth of Medicare spending, Congress implemented prospective limits on hospital costs reimbursed by Medicare (Rich et al 2002; Young & Coffman 1998). However, the policy was amended in 1979 so that no direct costs of GME programs would count towards this limit (Rich et al 2002; Young & Coffman 1998). The next year, reimbursement limits on teaching hospitals were increased to reflect the higher operating costs associated with treating patients in those hospitals (Rich et al 2002; Young & Coffman 1998).

In 1984, GME funding switched from a retrospective cost-based reimbursement system, under which Medicare reimbursed hospitals for their actual expenditures in a given year, to a prospective payment system, under which Medicare used a formula that allocated funding to hospitals based on costs incurred in a base year period (for most hospitals fiscal year 1984) divided by the number of residents counted in the base year (Rich et al 2002; Young & Coffman 1998). Under the prospective payment system, a hospital's Medicare reimbursement funds in a given year were no longer tied to actual incurred costs in that same year (Rich et al 2002; Young & Coffman 1998).

In addition to direct medical education costs, Medicare provides funding for the costs of indirect medical education (IME), expenses related to the higher marginal cost of treating a patient in a teaching hospital compared to a non-teaching hospital. Among other factors, IME funding is intended to adjust for the greater severity of illness associated with patients in teaching hospitals, increased inefficiencies in teaching, and greater concentration of technology (Rich et al 2002). However, the magnitude of the IME adjustment has been controversial since its inception (Rich et al 2002). Since the formula for IME payment relies on the ratio of medical residents to hospital beds, and a higher IME payment can result in millions of additional dollars in funding, Congress became concerned that it had inadvertently created an incentive for hospitals to take as many medical residents as possible in order to increase their resident-to-bed ratio and secure more Medicare funding (United States Government Accountability Office 2018)

To address this concern, the Balanced Budget Act of 1997 introduced a hospital-specific cap on the number of medical residents that Medicare would financially support each year (United States Government Accountability Office 2018). The cap was set at each hospital's number of residents in 1996; any hospital may train additional residents above its cap, but the hospital will not receive additional Medicare payments for those trainees (Eden 2014). The caps do not change over time and make no adjustments for changes in the demography of the U.S. population (Eden 2014). Eden (2014) points out that, "as a result, the highest density of Medicare-supported slots and Medicare GME funding remains in the Northeast." Residency caps for new teaching hospitals, or for new residency programs at existing teaching hospitals, are set at the highest number of FTE residents the program trains in any one of its first five years.

In 2015, Medicare spent over 10 billion dollars on graduate medical education (United States Government Accountability Office 2018). However, Chen et al (2013) point out that "despite the size of GME investment in the physician workforce, there is little accountability for how these public investments affect workforce outcomes, such as specialty and geographic distribution." The Centers for Medicare and Medicaid Services (CMS) does not collect information to assess the outputs or outcomes of GME funding related to healthcare workforce planning (United States Government Accountability Office, 2018).

Section 5503 of the Patient Protection and Affordable Care Act, passed in 2010, attempted to achieve a more efficient distribution of Medicare-funded residency slots by reducing the GME cap for hospitals whose number of trainees fell below the official cap for the three most recent cost reporting periods. Hospitals with unused spots were eligible to lose 65 percent of the difference between the resident cap (determined by Medicare in 1997) and the resident count (determined from three most recent cost reports). For example, if a hospital had a resident cap of 20 full-time equivalent (FTE) residents, but only trained 9 residents during the three most recent cost reporting periods, then this hospital would be eligible for a cap reduction of 7 slots. As a result of this reduction, CMS could then increase the residency cap at other hospitals by a total of no more than 7 slots.

In total, 726 graduate medical education slots were redistributed to 58 hospitals under Section 5503 of the Patient Protection and Affordable Care Act. The 2011 residency redistribution was not unprecedented. The Medicare Prescription Drug, Improvement, and Modernization Act of 2003 redistributed nearly 3,000 residency positions, increasing the cap at 304 hospitals in 2005. Two key policy goals of this redistribution were to train more residents in primary care and rural areas. However, a 2013 analysis of the impacts of this redistribution found that the policy failed to meet these goals. The analysis used data from the CMS Healthcare Cost Report Information System on residency caps, total number of residents trained, number of primary care and obstetrics and gynecology physicians trained, and number of all other residents trained from 1998 to 2008 (Chen et al 2015). The authors found that only 12 out of 304 hospitals receiving additional spots were rural, and they received fewer than 3 percent of redistributed slots. Furthermore, the relative growth of non-primary care training as a result of the policy was twice as large as the growth of primary care training.

Literature Review

To date, no analysis has been conducted on the effect of residency redistribution on hospital quality. There is some literature supporting the hypothesis that an increase in the number of medical residents in a given hospital may lead to an increase in quality of care. Zallman et al (2010) used data from 33,900 hospital-based outpatient visits from the 1997-2004 National Hospital Ambulatory Medical Care Survey (NHAMCS) in order to assess the quality of US primary care delivered by resident and staff physicians. This study examined 20 measures of primary care quality and compared resident and staff physician performance on 19 quality indicators, controlling for patient sex, age, race/ethnicity, insurance, and metropolitan status. On 4 of these 19 quality indicators—ACE inhibitor use for congestive heart failure, diuretic use for hypertension, statin use for hyperlipidemia, and routine blood pressure screening—residents outperformed staff physicians; on the remaining 15 indicators, performance was similar between the two groups.

In a literature review of 23 studies comparing quality of care in teaching versus non-teaching hospitals, Kupersmith (2005) found that most studies showed quality of inpatient care to be higher in teaching hospitals than in nonteaching hospitals. In evaluations of both process measures and outcome measures, teaching hospitals outperformed nonteaching hospitals. These findings extend over a range of locations, conditions, and populations, and persist when examining both highly specialized and routine care. A limitation of this research is that studies on quality of care are "by their nature observational, usually retrospective, and usually characterized by nonrandom selection" (Kupersmith 2005). The Kupersmith analysis does not identify the causes of the quality disparity between teaching and non-teaching hospitals; however, in conjunction with the research on resident quality of care by Zallman et al, this literature review provides additional support for a positive correlation between number of medical residents and hospital quality.

Additionally, no analysis has been conducted on the effect of residency cap increases on the local healthcare workforce. Previous research has indicated that physician assistants and nurse practitioners may serve as substitutes for physician residents in teaching hospitals, suggesting that an increase in medical residents may lead to a decrease in the number of physician assistants and nurse practitioners (Riportella-Muller et al 1995). A 14-month long observational study of nurse practitioners, physician assistants, and medical resident care activities found that "the tasks and activities performed by acute care nurse practitioners and physician assistants are similar to those performed by resident physicians" (Rudy et al 1998). Patient outcomes were similar for nurse practitioners and physician assistants when compared to resident physicians; however, medical residents treated patients who were sicker and older on average.

Another important aspect of the relationship between GME funding and the healthcare workforce is the effect of a physician's geographic location during her residency program on her long-term practice location. Increasing severity of rural physician shortages over the past 20 years have drawn attention to the study of "pipeline" programs designed to retain physicians in rural areas after completing their GME (Brooks et al 2002). However, there has been a lack of academic research on general patterns of correlation between the geographic location of a physician's medical residency and first practice.

There is some evidence that physicians' first practice sites are influenced by the geographic location of their medical residencies. In a sample of 2,612 physicians, Dorner, Burr, and Tucker (1991) found that 40% of physicians' first practices were located less than 10 miles from their residencies, and over 50% were within 75 miles. Another survey of 358 graduate physicians by West et al (1996) found that nearly two thirds of family physicians stay in their first practice location until retirement. They also found that primary care physicians moved significantly shorter distances than did those from other specialties. Steele et al (1998) found in a survey of 441 physicians that 43% chose to practice in the same city or metropolitan area in which they trained, and 46% of those who stayed nearby had no personal tie to the area before their residency. Using data from the American Medical Association Physician Masterfile, Seifer, Vranizan, and Grumbach (1995) found wide variation among states in the proportion of physicians who remained in the same state where they completed their residency; however, they did note that primary care physicians were nine percentage points more likely than specialists to remain in their state of GME. These studies support the hypothesis that an increased number of GME slots at a given hospital may cause a corresponding increase in the number of physicians practicing in the local area, beginning as soon as three years (the shortest period of medical residency) after the implementation of the slot increase.

Data

Center for Medicare and Medicaid Services and HUD Administrative Data

The Center for Medicare and Medicaid Services (CMS) website contains publicly-available information regarding which hospitals experienced cap increases, which hospitals experienced cap decreases, the size of each increase/decrease, and which states had hospitals that were eligible but did not receive additional funding under Section 5503. The primary CMS document on Section 5503 GME redistribution identifies hospitals using a Provider ID number, which was matched to information about the hospital's name and address using the CMS "Hospital General Information" database. From there, hospitals were matched to their FIPS county code using a ZIP-FIPS crosswalk available from the Department of Housing and Urban Development (HUD).

Robert Graham Center GME Tables/ CMS Cost Reports

Yearly data on the number of FTE and primary care FTE residents per hospital is drawn from the Robert Graham Center, which originally sources its data from the CMS cost reports. In order to receive DME and IME payment from CMS, a hospital must supply CMS with an annual fiscal cost report. The annual cost report is sent to an intermediary agency that reviews the initial report, and then it is submitted to CMS. The information may then be audited by CMS approved financial auditors. Due to audits and reconciliation of reports, any values that are three years old or newer are still subject to change. For this reason, only FTE counts through 2015 are included in this paper's analyses.

Area Health Resource File

The Area Health Resource File (AHRF) combines information from over 50 data sources to provide county-level information (using FIPS county codes) on a variety of health care utilization, health professions and facilities, environmental, and sociodemographic topics. In this paper, the AHRF is utilized to estimate outcome variable related to the healthcare workforce: namely, number of physicians and physician assistants in a given county and year. The AHRF is also the source of demographic covariates such as population size, racial composition, and average education level.

Center for Medicare and Medicaid Services Hospital Compare

The Hospital Compare database contains information on readmissions, mortality, and patient satisfaction surveys from 2007-2016. This database uses the same Provider ID as the CMS administrative data on Section 5503, allowing for a direct comparison between hospitals that did and did not receive cap increases. Readmissions and mortality measures in the Hospital Compare data focus on three conditions: acute myocardial infection (AMI), heart failure (HF), and pneumonia (PN). Patient satisfaction ratings from the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS).

Methods

Identification strategy

Section 5503 of the Affordable Care Act mandated the redistribution of over 700 DGME funding slots. This redistribution was accomplished by lowering the Medicare-funded DGME cap at hospitals that had trained fewer than the maximum allowable number of residents during each of the previous three years. These “excess” spots were awarded to hospitals in states that met one of the following criteria:

1. The hospital is located in a state with a resident-to-population ratio in the lowest quartile: Montana, Idaho, Alaska, Wyoming, South Dakota, Nevada, North Dakota, Mississippi, Indiana, Puerto Rico, Florida, Georgia, or Arizona

2. The hospital is located in a rural area
3. The hospital is located in one of the 10 states with the highest proportion of its population living in a health professional shortage area: Louisiana, Mississippi, Puerto Rico, New Mexico, South Dakota, the District of Columbia, Montana, North Dakota, Wyoming, or Alabama

70 percent of slots were reserved for hospitals meeting criteria 1, while the remaining 30 percent of unused spots were allocated to hospitals meeting criteria 2 or 3.

Despite these restrictions on which hospitals were allowed to apply for additional DGME slots, the Center for Medicare and Medicaid Services announced in 2012 that the agency had “ran out of slots during the redistribution process and were unable to award any slots to hospitals in qualifying, but lower ranking, States.” Two hospitals that applied and qualified for slots in Florida (which is ranked 11th under criteria 1) did not receive any additional funding. No slots were awarded to seven Georgia hospitals (Georgia is ranked 12th under criteria 1) or eight Arizona hospitals (Arizona is ranked 13th under criteria 1) that applied because all available slots were already granted to hospitals in states ranked 1 through 11. Additionally, one hospital in Alabama (which is ranked 10th under criteria 3) did not receive any of the slots that it was qualified to receive.

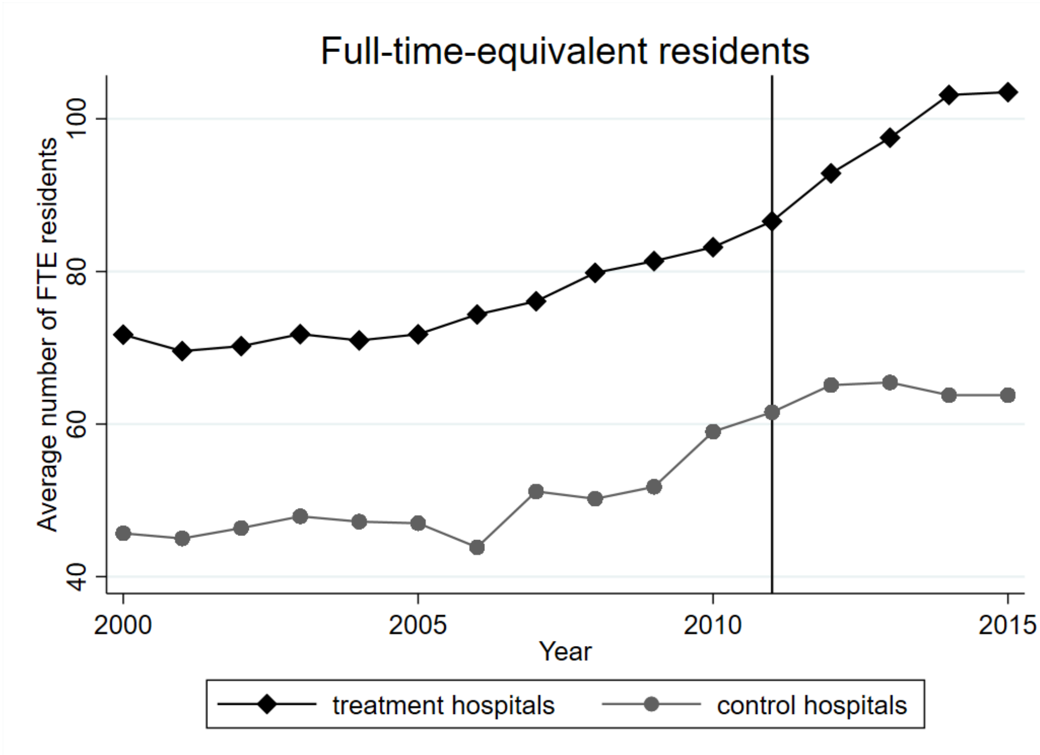
This paper uses hospitals/counties in three states that were eligible to receive additional funding under criteria 1-3, but where CMS “ran out of slots”- Florida, Arizona, and Alabama- as a control group for the hospitals/counties that received a DGME cap increase of 5 or more slots. Georgia was excluded from the analysis due to a state GME expansion initiative that began in 2013.

Sample selection

Selection of the treatment group began with the list of 58 hospital provider numbers listed by CMS in the public document announcing hospitals that would receive increased GME funding under Section 5503. These provider numbers were matched with each hospital's ZIP code using the "Hospital General Information" dataset, and finally to a FIPS code using the HUD ZIP-FIPS crosswalk (or manual matching when necessary). Since some hospitals received such a small cap increase under Section 5503 that they were under nearly the same conditions as the control group, a treatment intensity cutoff was established for inclusion in the treatment group. A county was included in the treatment group if the sum of DGME cap increases for all hospitals in that county was greater than five slots. Although some DGME slots were redistributed to hospitals in Puerto Rico, AHRF did not include data on those geographic areas, and thus they were excluded from the analysis. In total, 24 counties from 11 states were included in the treatment group for county-level outcomes, and 34 hospitals were included in the treatment group for quality outcomes.

The control group was selected from hospitals that reported receiving some graduate medical education funding from Medicare, as documented on their CMS cost reports. First, the group was limited to hospitals in Florida, Arizona, and Alabama. Using the same matching process as for the treatment group, these hospitals were then paired with their FIPS codes, and counties were eliminated from the control group if they already contained a treatment hospital. Two counties were also excluded from the control group because they contained hospitals who received extra DGME spots in 2012 under another policy, section 5506 (redistribution of slots from closed hospitals). Fourteen counties were included in the control group for county-level outcomes, and 65

FIGURE I: PARALLEL TRENDS IN FTE RESIDENTS



hospitals were included in the control group for quality outcomes.

In order to confirm that the cap increases declared by CMS truly aligned with the funding constraints experienced by hospitals in the sample, Figure I below plot the average number of full-time-equivalent residents in treatment versus control hospitals. The increased slope for treatment hospitals after 2011 indicates that treatment hospitals did in fact increase their number of graduate medical residents in response to the Section 5503 cap redistribution; a similar increase was not observed among the control hospitals.

Empirical strategy

This paper uses a difference-in-differences approach to estimate the effect of Medicare-funded graduate medical education on the number of medical residents and healthcare quality, both measured at the hospital level, and on the supply of healthcare professionals, measured at the county level. For each outcome of interest, the effect of increased DGME funding (if it exists) will likely amplify over time for two reasons: hospitals may take several years to expand their residency program to reach the new caps, and each additional resident who does choose to practice in the county of their residency must train for a minimum of three years before becoming a licensed physician. An event study framework is utilized to incorporate this feature of the policy. The regression model is given by:

$$y_{it} = a_i + \gamma_t + x_{it}\beta + \sum_{k \neq p} T_{it}^{k}\delta_k + \varepsilon_{it}$$

where T_{it} equals the size of the DGME increase assigned to hospital/county *h* if it was granted a cap increase *k* years ago (or, if *k* is negative, will receive a cap increase *k* years in the future). The last pretreatment period is represented by *p;* thus, δ_k represents the difference between treatment and control counties/hospitals in period *t*, with the last pretreatment period used as the reference. The "fixed effect," a_i, summarizes the impact of permanent differences among hospitals/counties in observed and unobserved characteristics. The γ_t's are the coefficients of a set of dummy variables for each year in the sample period that capture the general time patterns for each outcome of interest. x_{it} is the vector of population covariates corresponding to county/hospital *h* in year *t*. All analyses at the county level incorporate population covariates related to race, education, and poverty from the AHRF.

An assumption of the difference-in-differences model requires that treatment and control groups experience parallel trends in the outcome variables prior to the policy intervention being evaluated. Appendix A uses graphs provide evidence in for parallel trends between the treatment and control hospitals and counties for all outcome measures in the analysis.

Limitations

Although CMS published information on which states had not received cap increases because they “ran out of slots,” provider numbers for the hospitals under consideration in these states were not published online. Thus, the control group in this paper is broader than the true pool of hospitals to which CMS considered allocating GME slots, making it a less accurate counterfactual for what would’ve happened to hospitals in the control group if they had not received cap increases.

Another limitation is the scarcity of pre-treatment data from the AHRF. For outcomes like the number of nurse practitioners, which only have two widely-spaced pre-treatment observations, we can be less certain that parallel trends assumption holds between the treatment and control groups.

Pre-treatment data is also limited in the Hospital Compare dataset. In recent years, CMS has added many clearly-interpretable quality variables to its publicly-available data, such as all-patient readmission rates, time from door to discharge, and a new 5-star overall quality rating. However, none of these variables appear in the data until after 2011, making them unusable for this difference-in-differences analysis. The mortality and readmissions data that is used instead relates to less-generalizable outcomes about critical, but less common health conditions.

Results

Effects of the policy on the number of residents

Table I summarizes the regression results for outcomes related to the total number of residents per county. The coefficients of interest in each regression represent the difference in outcomes between the treatment and control counties for each post-treatment year. Regression 1 shows a positive relationship between the number of full-time-equivalent residents and the size of the DGME cap increase; however, this correlation is not significantly different form zero until two years after the cap increase, at which point a positive and significant relationship emerges. Interestingly, the difference-in-differences coefficient exceeds one during the third and fourth years after treatment. The 90% confidence interval for these coefficients still overlaps with one (see Figure C1 in Appendix C); nonetheless, these results may suggest that an increased GME cap causes an increase in medical training beyond the number of residents who are trained directly using Medicare funds.

Regression 2 shows that there is also a positive relationship between the cap increase and the number of primary care residents, which is not significant until three years after the cap increase. In the last year of available data, four years after the DGME cap increase, the coefficient on number of primary care FTEs is 0.591, while the coefficient on the total number of FTEs is 1.608. Thus, the impact of the DGME cap increase seems to be divided between primary care and specialty positions.

TABLE I: NUMBER OF RESIDENTS

VARIABLES	(1) Total FTE	(2) Primary care FTE
0 years post-treatment	0.219	-0.0426
	(0.324)	(0.114)
1 year post-treatment	0.304	-0.0135
	(0.202)	(0.153)
2 years post-treatment	0.660***	0.158
	(0.217)	(0.171)
3 years post-treatment	1.168***	0.458**
	(0.307)	(0.220)
4 years post-treatment	1.608***	0.591**
	(0.588)	(0.274)
Constant	37.59	47.37
	(66.76)	(37.27)
Observations	228	228
R-squared	0.578	0.407
Number of FIPS codes	38	38
Country FE	YES	YES
Year FE	YES	YES

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Spillovers: general healthcare workforce and quality of care

Table II shows the regression results for outcomes relating to the general healthcare workforce. Regression 1 shows that the change in the number of non-federal active MD's for treatment counties was not statistically different from the change experienced by control counties for at least five years after the cap increase. This result is consistent with the 2-year lag in the number of residents revealed in Table I, since medical residency programs are a minimum of three years in length. Regression 2 shows that the change in supply of nurse practitioners for treatment counties was not significantly different from the change experienced by control counties for the first four years after the policy change; however, by the fifth post-treatment year there had emerged a positive and statistically significant relationship, suggesting that every one-physician increase in the DGME cap is correlated with and 3.6 additional nurse practitioners.

Tables III, IV, and V present regression results on mortality, readmissions, and patient satisfaction respectively. There were no statistically significant results on any quality measures in the analysis for the first five years after treatment at the hospital level. Thus, funding for medical residents seems to have no impact on either the *true* quality of treatment (as observed by patient outcomes for acute myocardial infection, heart failure, and pneumonia), nor the *perceived* quality of treatment (reflected in patient satisfaction scores).

TABLE II. GENERAL HEALTHCARE WORKFORCE

VARIABLES	(1) Total active MD's	(2) Nurse practitioners
0 years post-treatment	-0.779	-0.00764
	(0.894)	(0.277)
1 year post-treatment	-0.998	0.180
	(0.765)	(0.466)
2 years post-treatment	-1.080	0.493
	(0.793)	(0.441)
3 years post-treatment	-0.415	1.012
	(0.788)	(0.614)
4 years post-treatment	0.0873	1.829**
	(1.063)	(0.844)
5 years post-treatment	1.868	3.601**
	(1.230)	(1.474)
Constant	-223.0	-1,685***
	(199.0)	(174.4)
Observations	266	266
R-squared	0.848	0.895
Number of FIPS codes	38	38
Country FE	YES	YES
Year FE	YES	YES

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE III: HOSPITAL MORTALITY REGRESSIONS

VARIABLES	(1) AMI adjusted 30 day mortality rate	(2) HF adjusted 30 day mortality rate	(3) PN adjusted 30 day mortality rate
3 years pre-treatment	0.000201	-0.000101*	0.000189**
	(0.000124)	(5.90×10^{-5})	(7.27×10^{-5})
2 years pre-treatment	2.18×10^{-5}	7.70×10^{-5}	0.000121**
	(9.25e-05)	(5.70×10^{-5})	(5.64e-05)
0 years post-treatment	6.10×10^{-5}	3.84×10^{-5}	-1.00×10^{-5}
	(0.000149)	(0.000106)	(0.000112)
1 year post-treatment	9.11×10^{-5}	1.65×10^{-5}	-0.000141
	(0.000149)	(0.000104)	(0.000118)
2 years post-treatment	0.000252	9.60×10^{-5}	-0.000166
	(0.000171)	(0.000147)	(0.000119)
3 years post-treatment	0.000218	8.71×10^{-5}	-0.000128
	(0.000161)	(0.000132)	(0.000124)
4 years post-treatment	0.000163	8.52×10^{-5}	0.000116
	(0.000152)	(0.000153)	(0.000152)
5 years post-treatment	0.000103	5.15×10^{-5}	6.36×10^{-5}
	(0.000149)	(9.62×10^{-5})	(0.000135)
Constant	0.160***	0.110***	0.111***
	(0.00119)	(0.00136)	(0.00113)
Observations	809	846	843
R-squared	0.355	0.077	0.730
Number of hospitals	88	89	89
Hospital FE	YES	YES	YES
Year FE	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE IV: HOSPITAL READMISSION REGRESSIONS

VARIABLES	(1) AMI adjusted 30 day readmission rate	(2) HF adjusted 30 day readmission rate	(3) PN adjusted 30 day readmission rate
3 years pre-treatment	$4.64x10^{-5}$	$-9.17x10^{-5}$	$6.25x10^{-5}$
	(0.000113)	(0.000146)	(0.000158)
2 years pre-treatment	$-5.45x10^{-5}$	$-6.52x10^{-5}$	$2.60x10^{-5}$
	$(9.81x10^{-5})$	(0.000103)	(0.000117)
0 years post-treatment	$9.93x10^{-6}$	$8.54x10^{-5}$	$-2.97x10^{-5}$
	$(5.71x10^{-5})$	$(8.30x10^{-5})$	$(8.43x10^{-5})$
1 year post-treatment	$9.32x10^{-5}$	$7.47x10^{-5}$	-0.000160
	(0.000106)	(0.000115)	(0.000108)
2 years post-treatment	0.000120	$9.24x10^{-5}$	-0.000116
	(0.000136)	(0.000159)	(0.000127)
3 years post-treatment	$7.52x10^{-5}$	$5.02x10^{-6}$	$-5.54x10^{-5}$
	(0.000169)	(0.000167)	(0.000136)
4 years post-treatment	$5.99x10^{-5}$	$2.42x10^{-6}$	$1.43x10^{-5}$
	(0.000174)	(0.000176)	(0.000145)
5 years post-treatment	$-3.26x10^{-5}$	$-4.83x10^{-5}$	$-2.31x10^{-5}$
	(0.000158)	(0.000178)	(0.000139)
Constant	0.197***	0.241***	0.182***
	(0.00153)	(0.00162)	(0.00182)
Observations	706	762	757
R-squared	0.633	0.459	0.185
Number of hospitals	82	86	86
Hospital FE	YES	YES	YES
Year FE	YES	YES	YES

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE V: PATIENT SATISFACTION REGRESSIONS

	(1)
VARIABLES	HCAHPS overall score
2 periods pre-treatment	$-9.71\text{x}10^{-5}$
	(0.000420)
0 periods post-treatment	-0.000257
	(0.000343)
1 period post-treatment	-0.000235
	(0.000512)
2 periods post-treatment	$-8.82\text{x}10^{-5}$
	(0.000638)
3 periods post-treatment	-0.000334
	(0.000762)
4 periods post-treatment	-0.000433
	(0.000780)
5 periods post-treatment	0.000116
	(0.000743)
Constant	2.464***
	(0.0193)
Observations	855
Number of hospitals	89
R-squared	0.425
Hospital FE	YES
Year FE	YES

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Discussion

Despite the enormous public investment in graduate medical education, this paper represents one of first empirically based efforts to estimate the impacts of GME-related public policy. The results indicated a positive effect of increased Medicare DGME funding on the total number of FTE residents, which became significant two years after the cap redistribution and continued to increase in years three and four. In the third and fourth years after treatment, the coefficient on the total number of FTE residents was greater than one, which may suggest that an increased GME cap causes an increase in medical training beyond the number of residents who are supported directly using Medicare funds. One possible explanation for this observation is that some hospitals use their increased GME funding to create new residency programs, as the creation of a new training program activates a 5-year period in which hospitals may earn even more federal funding slots. Investigation into the number of distinct residency programs at each hospital receiving Medicare DGME funding would contribute to a clearer understanding of the relationship between resident caps and the total number of residents.

There was also a positive correlation between the cap increase the number of primary care residents, which became significant three years after the initial cap redistribution. While this increase in the number of primary care residents seems consistent with CMS's public goal of utilizing GME funding to increase the supply of primary care physicians, the analysis of a 2005 residency redistribution by Chen et al (2013) warns us to interpret this result with caution. A simple increase in the *number* of primary care physicians does not constitute the necessary shift in the distribution of medical specialties that is necessary to meet our nation's healthcare needs. In order to ameliorate current disparities and prevent future deficits in healthcare access, a greater *proportion* of physicians must choose to go into primary care.

The results of this paper, which revealed a sizeable difference between the coefficients on total number of FTE's and number of primary care FTE's, suggest that the number of additional medical residents entering specialty programs was at least as large as the increase in the number of primary care residents. The relative growth of primary versus nonprimary residencies among hospitals who receive increased DGME funding should be examined further in future research. Future research should also examine the likelihood of primary care physicians, relative to specialty physicians, practicing in the geographic area where they completed their residencies. Will more primary care physicians (versus specialty physicians) that were trained using Section 5503-related funds choose to practice locally, since the policy aimed to increase funding in areas with a high demand for these positions? This question can not be answered with the current data, but it is important for analyzing the perceived effectiveness of GME redistribution policies in addressing geographic health inequities.

Future research should also test for a relationship between total number of active MDs and DGME caps over a longer time horizon. This paper showed that hospitals who receive increased DGME slots typically require on adjustment period of up to two years before they even begin approaching their new cap. Since medical residencies take a minimum of three years, the time window for this study was simply too short to observe overall changes in county-level physician supply as a result of residents choosing to practice locally after completing their training. Further insight into the frequency with which primary care and specialty physicians choose to practice locally, as well as the long-term effects of an expanded medical residency program on the local physician labor market, will give policymakers better information on how DGME funding effects the market for healthcare as a whole.

This paper also presents the first known results relating DGME funding to non-physician healthcare occupations and finds a positive (though lagged) correlation between DGME caps and the number of registered nurses. The increase in the number of registered nurses became significant within three years of the cap redistribution, and indicated an increase of nearly four registered nurses for every additional DGME slot. The observed spillover effect on the number of registered nurses demonstrates that federal funding for DGME can have consequences for the healthcare labor market that extend beyond the supply of certified physicians. The effect of DGME funding on the supply of clinical support staff should be considered by future policymakers who wish to leverage federal GME funding as a tool to create a more efficiently-distributed healthcare workforce.

Although previous research has suggested that medical residents perform better than fully-trained physicians on some measures of quality, this paper found no significant effect of DGME funding on actual (measured using mortality/readmissions data) or perceived (measured using patient satisfaction surveys) quality of care. Nevertheless, future research may yield more precise results on the relationship between medical residency counts and hospital quality using the more comprehensive data that is currently available through Hospital Compare.

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APPENDIX A: SUMMARY STATISTICS

			Control					Treatment		
VARIABLES	N	mean	sd	min	max	N	mean	sd	min	max
% White	14	77.65	15.93	29.10	94	24	65.80	18.29	28.40	96.10
% Black	14	13.01	17.39	0.600	69.40	24	24.44	19.82	0.200	69.10
Native American	14	0.771	0.718	0.200	2.200	24	0.871	1.213	0.200	4.800
% Other race	14	4.436	3.516	0.200	12.80	24	3.775	3.972	0.600	16
% Two+ races	14	2.250	0.930	0.700	4	24	2.392	1.081	0.500	5.100
%Hispanic/Latino	14	13.74	10.01	0.700	32.40	24	13.52	15.86	1.500	65
% Less than HS education	14	13.33	4.937	7.500	25.80	24	12.11	3.070	6.900	19.40
% HS education or above	14	86.67	4.937	74.20	92.50	24	87.89	3.070	80.60	93.10
% College educated	14	25.48	9.478	11.50	41.50	24	30.64	8.445	11.50	55.40
Total population	14	546,553	989,390	14,972	$3.817x10^6$	24	686,364	637,873	34,690	$2.496x10^6$
Poverty rate	14	18.06	6.119	9.800	35.60	24	17.88	4.242	11.70	27.10
Average per capita income	14	34,165	5,116	25,801	42,273	24	38,764	8,443	28,640	70,710

APPENDIX B: PARALLEL TRENDS

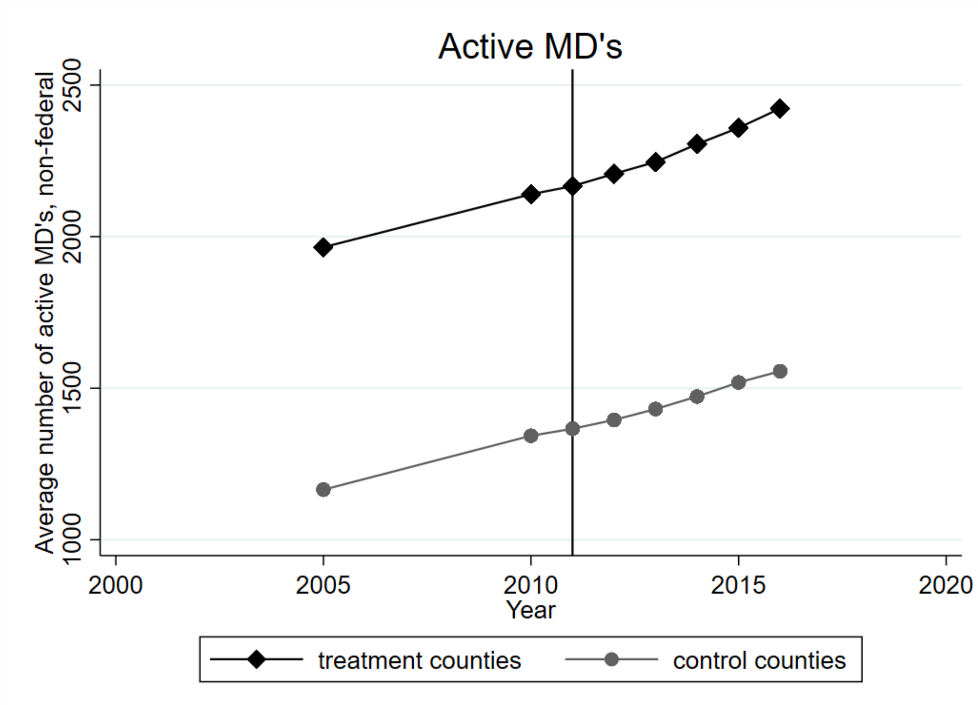


FIGURE B1. Parallel trends graph for the total number of active MD's at the county level. Source: AHRF

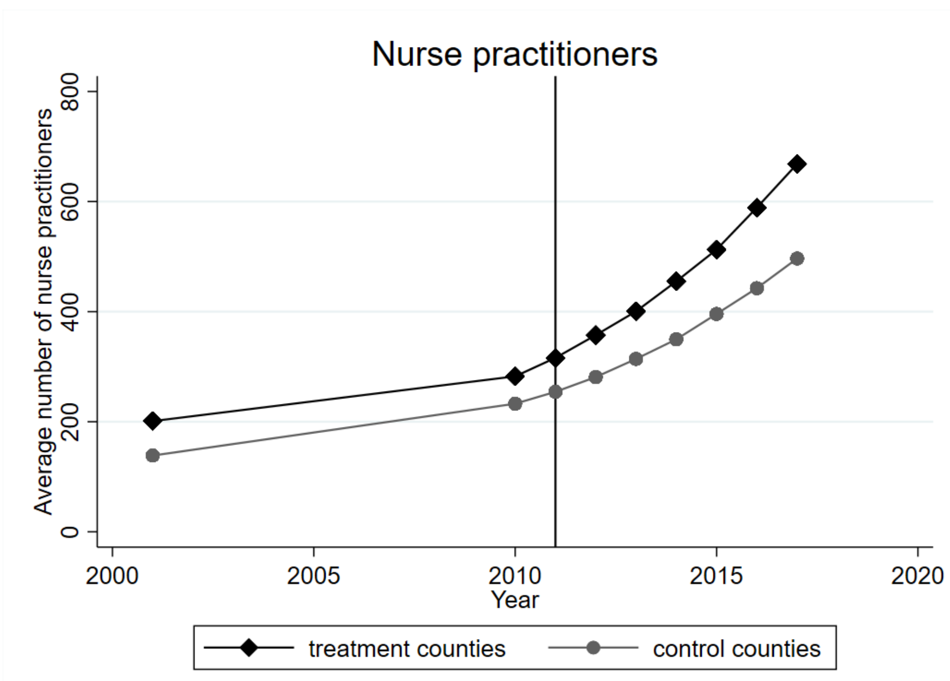


FIGURE B2. Parallel trend graph for total number of nurse practitioners at the county level. Source: AHRF

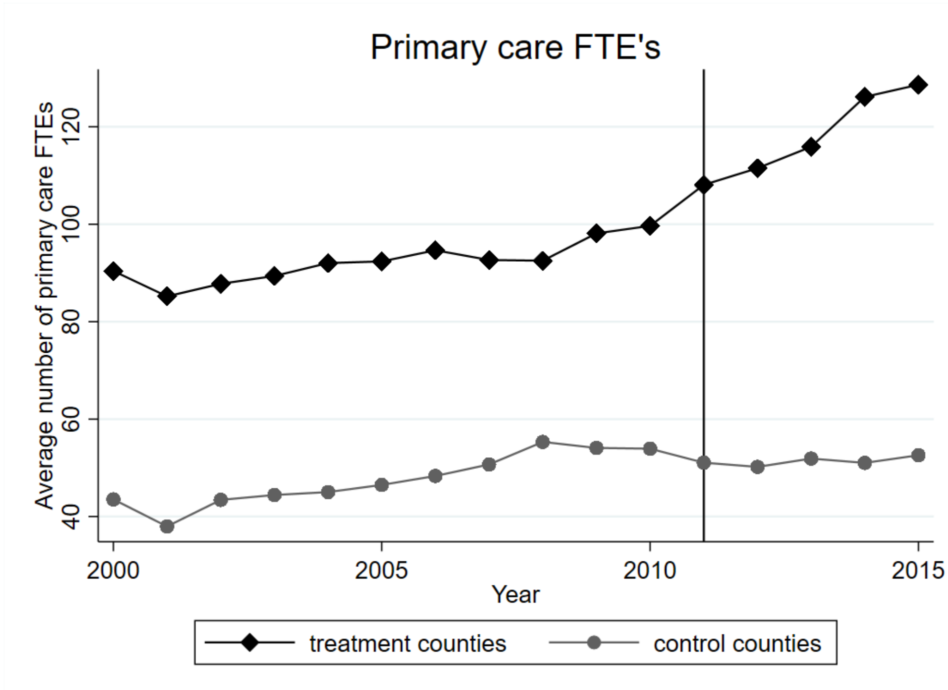


FIGURE B3. Parallel trend graph for total number of primary care full-time-equivalent medical residents at the county level. Source: CMS Cost Reports/Robert Graham Center

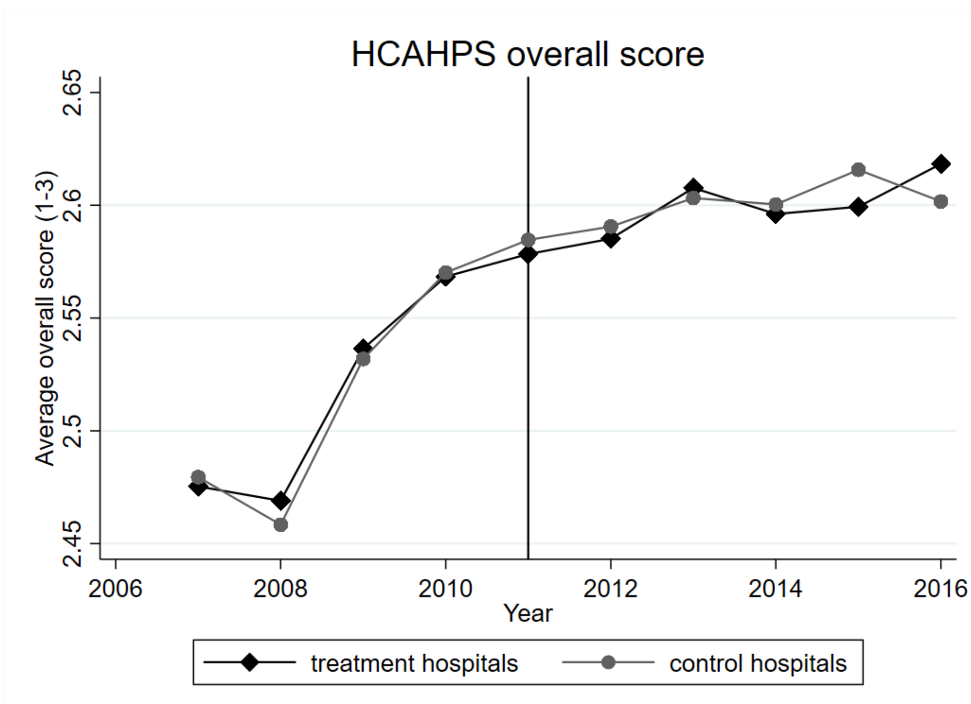


FIGURE B4. Parallel trend graph for Hospital Consumer Assessment of Healthcare Providers and Systems survey overall patient score. Source: CMS Hospital Compare

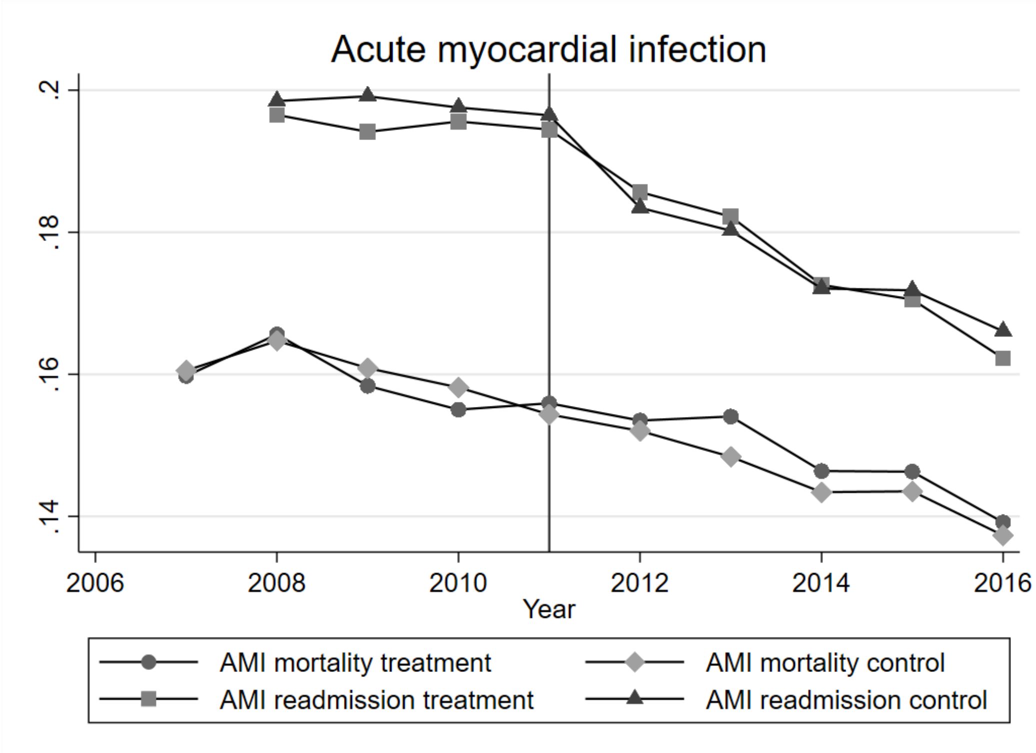


FIGURE B5. Parallel trend graph for acute myocardial infection mortality and readmission. Source: CMS Hospital Compare

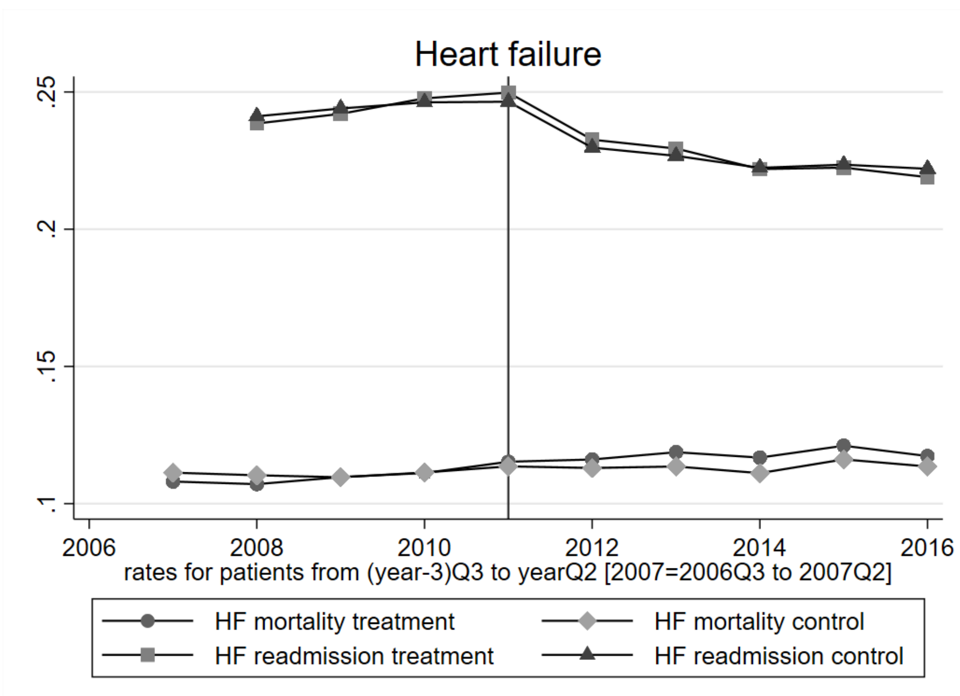


FIGURE B6. Parallel trend graph for heart failure mortality and readmission. Source: CMS Hospital Compare

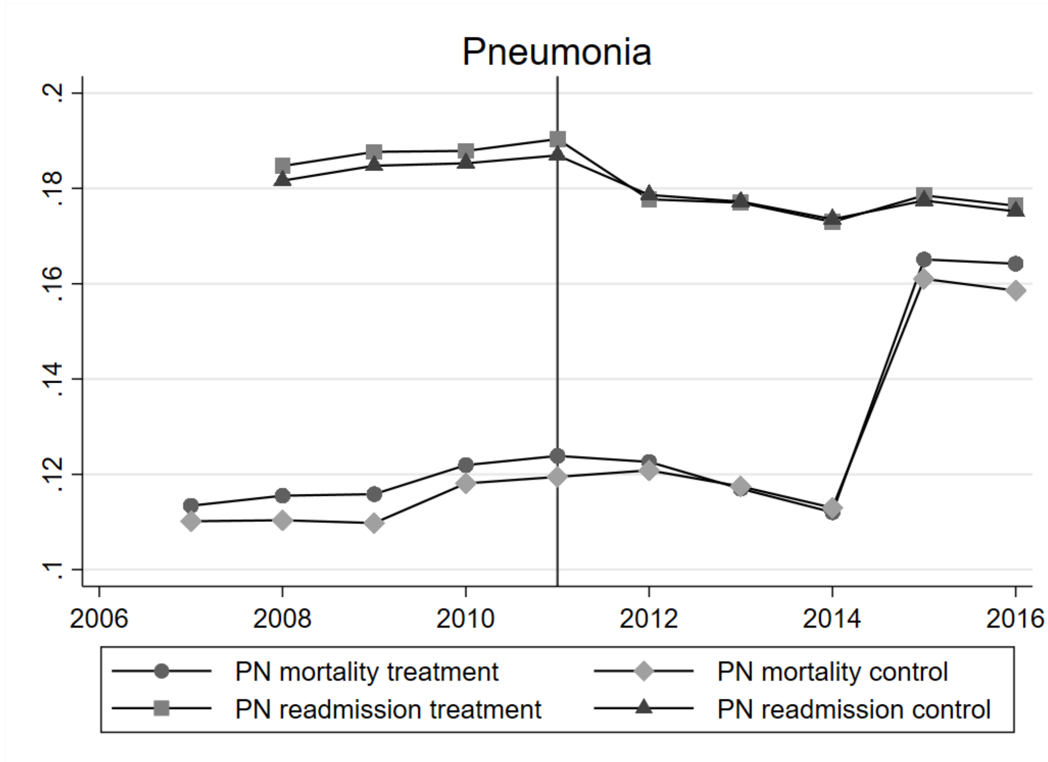


FIGURE B7. Parallel trend graph for pneumonia failure mortality and readmission.
Source: CMS Hospital Compare

APPENDIX C: RESIDENT COUNT EVENT STUDIES

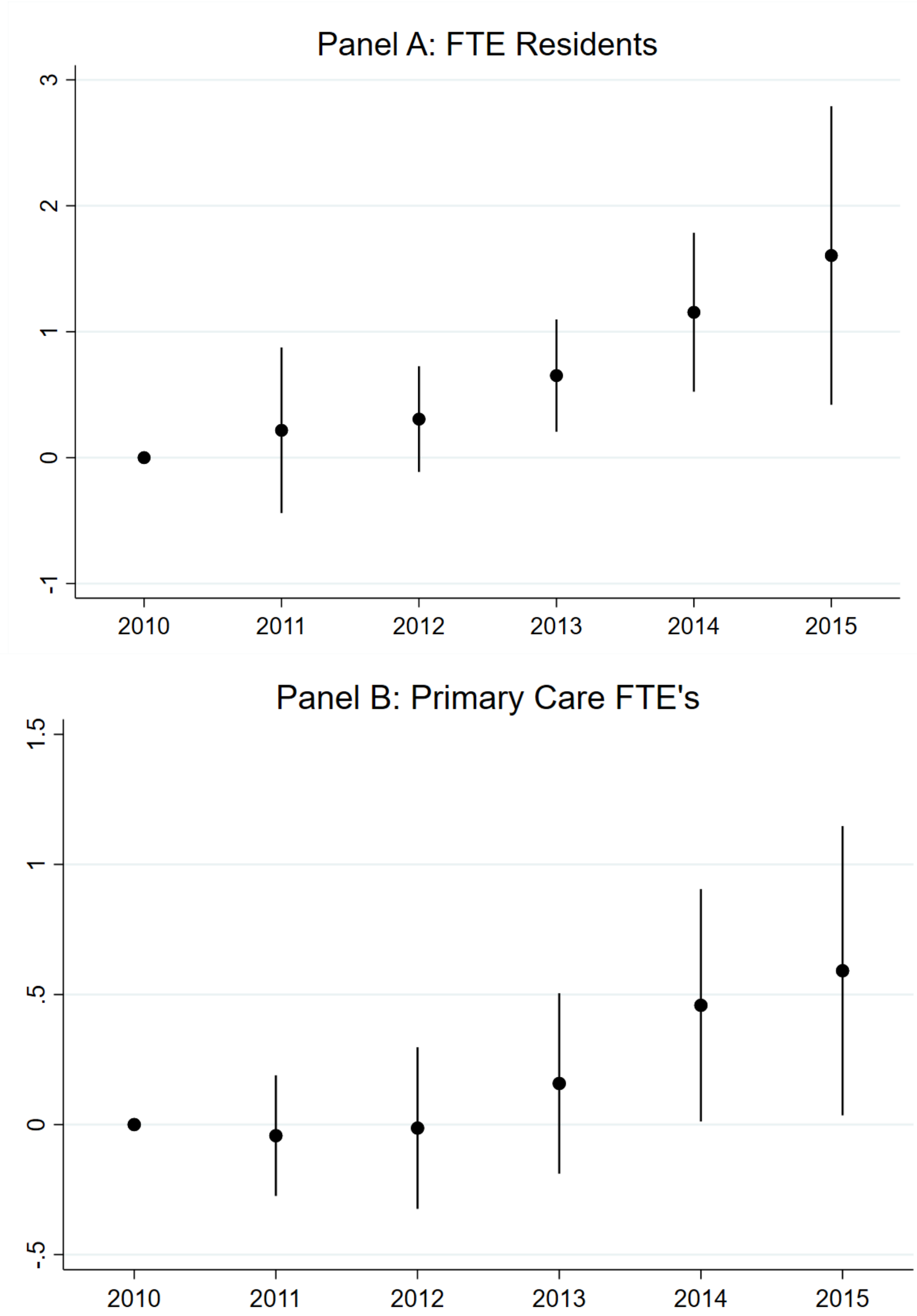
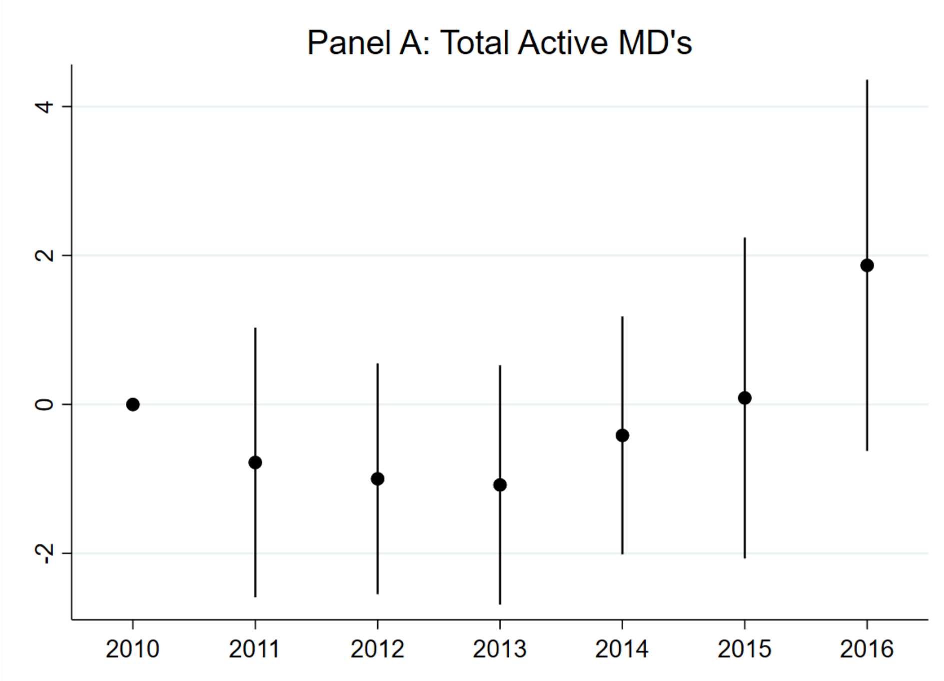


FIGURE C1. Event study plot for county-level number of full-time-equivalent residents (Panel A) and primary care FTE’s (Panel B). Plotted coefficients represent results from Table I. Bars represent 90% confidence interval.

APPENDIX D: HEALTHCARE WORKFORCE EVENT STUDIES



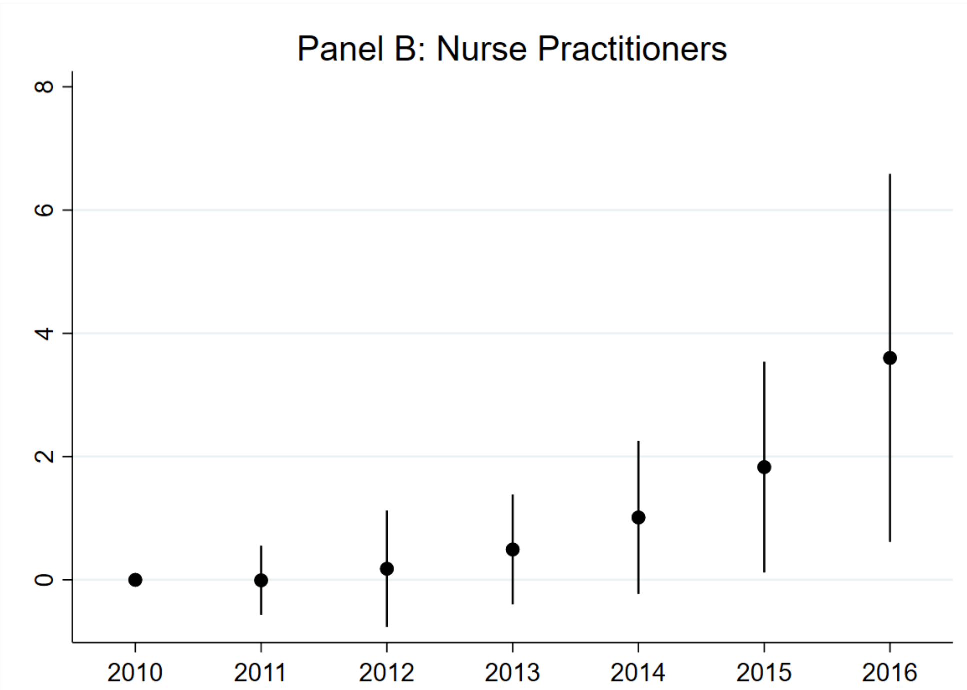


FIGURE D1. Event study plot for county-level number level number of total active MD's (Panel A) and nurse practitioners (Panel B) Plotted coefficients represent results from Table II. Bars represent 90% confidence interval.