Consolidations for Cost Savings? Hospital Mergers and Service Repositioning*

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Abstract

When confronted with antitrust challenges, hospitals seeking mergers frequently claim substantial cost savings from consolidating their services to achieve economies of scale. This paper explores whether merging hospitals eliminate duplicate services to save costs. We use the California Patient Discharge Data and Hospital Financial Report, and employ a difference-in-differences research design. We find that targets and acquirers located within 10 miles of each other eliminate about five duplicate services on average. These adjacent merging hospitals also become more specialized in their service offering, with the volume concentration measurement (Herfindahl-Hirschman Index) across services increasing by 10%. Compared to non-merged hospitals, the merging hospitals experience a 20% reduction in per-unit patient care costs for the consolidated services, a slight increase in patients' travel time, and no change in unexpected readmission rates. Service consolidation is not observed in more distant mergers. These results are robust to different service measurements and control strategies.

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1 Introduction

Mergers and acquisitions have become increasingly common in the health care industry, with more than 700 acquisition deals announced between 2011 and 2017 (Kaufman Hall, 2019). The standard antitrust concern is that such consolidations result in price increases due to reduced competition. The merging parties, however, argue that their proposed mergers will generate efficiency gains and cost reductions. While many published studies have examined the price effects of such mergers and found evidence of price increases (Dafny, 2009; Haas-Wilson and Garmon, 2009; Garmon, 2017; Lewis and Pflum, 2017; Cooper et al., 2018), there is limited systematic research about mergers' impact on cost savings.

A merger of competing hospitals could generate cost savings by eliminating duplicate services. And indeed, when confronted with antitrust challenges, hospitals seeking mergers frequently claim that they can generate substantial efficiency gains through service consolidation.[1] Theoretically, consolidation of duplicate services can benefit hospitals in several ways. First, eliminating duplicate services generates cost savings on hospitals' capital investment (such as medical equipment expenses) and payroll expenditures. Second, consolidating duplicate services to a single facility helps hospitals achieve scale economies. Third, there is the potential for better coordination of care among physicians when hospitals remove certain services and become specialized in others. Despite these potential benefits, hospitals may have difficulty consolidating services due to organizational, regulatory, or financial constraints. It is an open question whether hospitals remove duplicate services after mergers.[2]

In this paper, we examine hospital mergers in California between 2002 and 2014 and document how the merging health care systems reorganize their services. We investigate whether merged hospitals consolidate duplicate services, and we quantify the magnitude of service repositioning. In our baseline analysis, we use a difference-in-differences (DID) design to compare the service provision of merging hospitals before and after mergers. The data indicate that

[1]For instance, when the Federal Trade Commission (FTC) challenged the horizontal merger between OSF HealthCare and Rockford Health System, the hospitals stated that the proposed merger could generate "substantial efficiencies." The CEO of OSF asserted that they would achieve the savings by "consolidations of several services (such as trauma, women's and children's, and cardiovascular surgery)" and "combining patient volume [...] to meet or exceeds (the generally-accepted minimum patient volume) thresholds associated with improved outcomes", which both hospitals did not meet independently (The Federal Trade Commission, Doc. 9349, 2012). Similarly, to defend the proposed merger between the Penn State Hershey Medical Center and PinnacleHealth System, the defendants argued that they "intend(ed) to move low acuity cases from Hershey to Pinnacle and high acuity cases from Pinnacle to Hershey" to achieve service consolidation (The Federal Trade Commission, Doc. 9368, 2015).

[2]The Federal Trade Commission pointed out that there "may exist possible physician resistance and regulatory approval difficulty, ... numerous cultural, financial, regulatory and other practical issues", which may thwart a hospital's pursuit of service consolidation (*Federal Trade Commission* v. *OSF HealthCare System, and Rockford Health System*, No. 11 C 50344).

non-merging hospitals are different from merging hospitals on a range of pre-merger characteristics. To avoid bias due to direct comparison of merging and non-merging hospitals, we exclude non-merging hospitals from our baseline analysis. We use hospitals that merge later as the control group for hospitals that merge earlier. This strategy takes advantage of the variation in the timing of mergers and it relies on the assumption of parallel pre-trend across early-merging hospitals and later-merging hospitals. Given that hospitals typically have little control over the exact timing of when a merger is approved, the selection of merging time is not a primary concern. Our validity tests confirm that the parallel pre-trend assumption holds. We also construct control groups by matching merging hospitals with non-merging hospitals with similar pre-merger characteristics, and show the main results are robust.

We construct two measures of service repositioning: number of services offered and concentration of patient volume across services. For both measures, we define services based on procedure codes from the California Patient Discharge Data. Specifically, we map the procedures performed to services based on the Clinical Classification Software (CCS) Level 2 categorization of procedure codes.

For the first measure, we construct dummy variables indicating whether each service is offered in a hospital. We then examine the change after a merger in (1) the number of services offered at individual hospital level, and (2) the total number of services, and (3) the number of duplicate services by a pair of merging hospitals. We also examine whether service repositioning exists only for merging hospitals that are geographically close to one another. We find that merging hospitals removes approximately 4.6 services if the hospitals are within 10 miles of each other. The effect disappears when the merging hospitals are more distant. We also find that, on average, merging hospitals that are within 10 miles of each other remove 5.1 duplicate services, while the total number of services offered does not change significantly.

Second, we measure service offering based on the concentration of patient volume across services. While it may be difficult or undesirable to shut down a service entirely, hospitals might steer patients to one location to achieve scale economies.[3] Analyzing service volume allows us to identify this form of service repositioning, which is not captured in the analysis by the number of services. We find that the volume Herfindahl-Hirschman Index (HHI) across the services at the individual hospital level increases by 10%–12% for merging hospitals that

[3]Traditional work using aggregated hospital financial and output data finds mixed evidence about the existence of scale economies in hospital production. For instance, Carey (1997), Preyra and Pink (2006), Kristensen et al. (2012), and Gonçalves and Barros (2013) find evidence of scale economics in hospitals, while Dranove (1998) find limited evidence of scale economies. The literature on scope economies in hospital production is also inconclusive. Gaynor, Kleiner and Vogt (2015) use micro data to control output variation and find substantial scale economies and scope diseconomies in some services.

are within 10 miles of each other. When we aggregate the service volume of the merging pairs and build the HHI measurement across services for each merging pair, the HHI across services remains stable after mergers. These results suggest that the service composition remains stable for merging pairs and that service consolidation happens at the individual facility level. The effect is mainly due to individual hospitals in merging pairs switching services. We also find that service consolidation is most common in cardiac procedures, obstetrics and other women's services.

The last step of the empirical analysis explores whether service repositioning of merging hospitals leads to cost reductions, changes in the quality of care, and changes in patients' travel distance. We use the service-specific cost information from the California Hospital Financial Report and calculate a per-unit patient care cost for each service at each facility.[4] We compare the per-unit service cost of consolidated and non-consolidated services of merging hospital pairs, and we analyze the heterogeneous effect of service cost changes across merging pairs of different geographic distances. We find that consolidated services experience a cost reduction of 20%, which is roughly $277 for cardiac catheterization, and $13 for echocardiology services. For impacts on patients, unscheduled readmission rates of consolidated services remain stable after mergers, while patients' travel distance and time of patients increase by a insignificant amount.

This paper contributes to the growing literature evaluating the efficiency gains of horizontal mergers. Previous studies have found mixed evidence on whether mergers lead to cost reduction in the hospital industry. Some researchers find significant cost reductions after hospital mergers (Dranove and Lindrooth, 2003; Harrison, 2011; Schmitt, 2017), and others do not (Spang, Arnould and Bazzoli, 2009). Research on this topic typically searches for evidence of cost reductions directly in the hospital financial data. This paper offers new evidence on cost savings after mergers by studying service consolidation behaviors of merging hospitals. We find that service consolidation brings about significant cost savings for merging hospitals that are geographically close to each other.

This paper also adds new insights to the emerging literature exploring the mechanism of efficiency improvement after merger in the hospital industry. Craig, Grennan and Swanson (2018) find that hospitals can decrease costs by bargaining lower price when purchasing medical supplies. We identify another mechanism through which merging hospitals may reduce costs and improve efficiency: service consolidation. We highlight that this cost-saving mechanism

[4] Our cost measure includes the payroll expenditure for physicians, supplies, and capital costs such as leases, rentals, and equipment depreciation. We do not include costs that are unrelated to services, such as fiscal and administrative spending.

exists only for merging hospitals that are geographically close to each other. Prior literature shows that these mergers also lead to greater price increase (Dafny, 2009). Our results suggest that a critical question for policy makers is how to pass on to consumers the cost reductions that result from health care system mergers, especially mergers that are geographically close.[5] In contrast, the lack of service consolidation and cost savings for distant mergers in our data questions the value of such mergers, especially given that recent literature finds a price increase for these mergers (Dafny, Ho and Lee, 2019).

Our work also contributes to the literature on post-merger endogenous product choices of multi-product firms. Theoretical work by Gandhi et al. (2008) and Mazzeo, Seim and Varela (2013) explains that a merging firm may choose to reposition its products to differentiate from its merging partners. This repositioning might mitigate price increases after a merger. Product choice by merging firms has been investigated empirically in various industries and markets, including music radio (Sweeting, 2010, 2013; Berry, Eizenberg and Waldfogel, 2016), smartphones (Fan and Yang, 2016), the airlines (Ciliberto, Murry and Tamer, 2016), and shampoo (Mao, 2019). We contribute to this line of literature by documenting endogenous product choice in the hospital industry.

The rest of the paper is organized as follows: Section 2 describes the data and provides information about the sample. Section 3 outlines the empirical methodology and presents the results with the service repositioning patterns of merging hospitals. Section 4 presents the implications for providers and patients, including changes in providers' costs after repositioning, service quality analysis, and impact on patients' travel distance. Section 5 offers a discussion and conclusion.

2 Data

We use four data sources to study the service repositioning of merged hospitals: (1) Hospital Merger Activity Dataset (Cooper et al., 2018), (2) California Patient Discharge Dataset, (3) California Hospital Financial Report, and (4) American Hospital Association Annual Survey.

2.1 Hospital Merger Activity Dataset

The Hospital Merger Activity Dataset built by Cooper et al. (2018) provides information about horizontal hospital mergers. The data set contains a panel of hospitals from 2000 to 2014

[5] One potential choice for policy makers could be a price cap similar to the one implemented in the merger of Beth Israel Deaconess Medical Center and Lahey Health System.

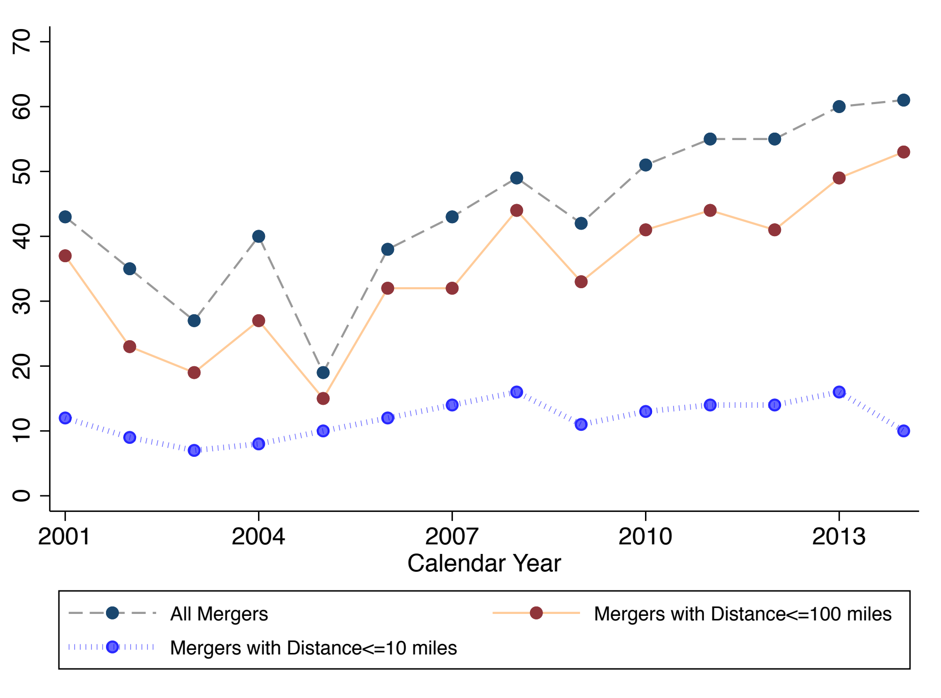


Figure 1: Hospital Merger Transactions, 2001-2014

and includes the following variables: the system identifier of hospitals, an indicator for whether the hospital is a target or acquirer in every year, and the longitude and latitude of hospitals.

Definition of a Merging Pair We categorize the mergers in the Hospital Merger Activity Dataset based on distances between merging entities. For two hospital systems involved in a merger, System S_1 and System S_2, let L and K stand for the number of hospitals belonging to each system, where $L \geq 1$ and $K \geq 1$. We denote these two systems $S_1 = \{H_1^1, H_2^1, .., H_L^1\}$ and $S_2 = \{H_1^2, H_2^2, .., H_K^2\}$, where H_i^s stands for a hospital i belonging to System $s \in \{1, 2\}$, with $i \leq L$ for S_1 and $i \leq K$ for S_2. For a hospital H_l^1 belonging to S_1, we call $H_1^2, H_2^2, .., H_K^2$ its merging counterparts because they are from the other system involved in the merger transaction. This merging hospital H_l^1 is said to have a merging counterpart within 10 miles if there exists a hospital H_k^2 from S_2 whose geographic distance from H_l^1 is no larger than 10 miles. This hospital pair (H_l^1, H_k^1) is called a within-10-mile merging pair. We define a merger transaction to be within 10 miles as long as there exists a hospital pair (H_l^1, H_k^2) whose distance is no larger than 10 miles.

Figure 1 summarizes horizontal hospital mergers in the United States from 2001 to 2014. The dashed line represents all transactions, the solid line is the number of mergers whose closest merging entities are less than 100 miles away, and the dotted line represents mergers of hospitals that are within 10 miles of each other. As shown in the figure, horizontal hospital mergers often involve hospitals that are geographically close to each other. A similar situation also exists in California. Figure 2 exhibits the scatter of merging hospitals in California in our sample we built (described in the next paragraph). The yellow points indicate merging hospitals that are within 10 miles of each other, blue points represent hospitals with merging counterparts that are between 10 and 100 miles away, and purple points represent mergers between hospitals that are more than 100 miles away from each other. There exists a nontrivial proportion of geographically close mergers.

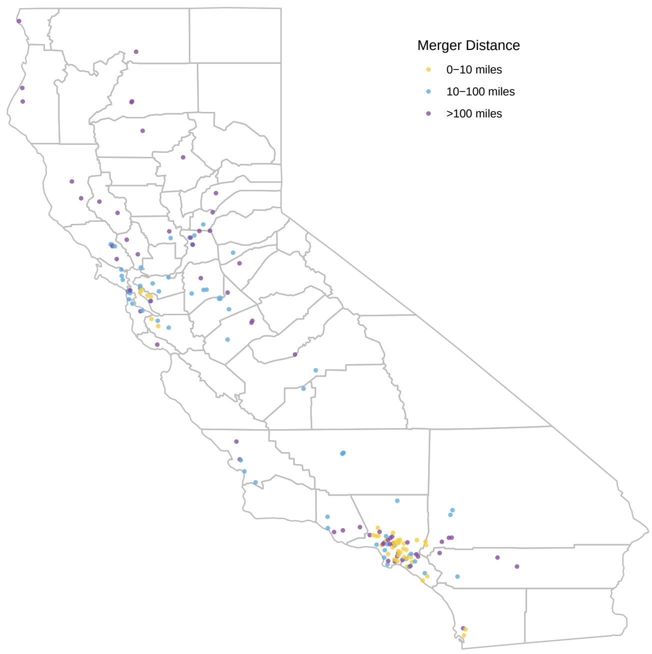


Figure 2: Merging Hospitals in California by Distance

2.2 California Patient Discharge Data

All nonfederal California-licensed hospitals are required to report every patient discharge record from their facilities, and we use these discharge data from 2002 to 2014 to determine which services each hospital offered. Each reported discharge includes detailed patient demographic information, the diagnoses and procedures related to the discharge in the form of International Classification of diseases (ICD-9) codes, and charges based on the listed price.

Service Definition using Patient Discharge Data For the baseline analysis, we define the services based on the procedures hospitals performed. In the California Patient Discharge Data, each discharge record includes the detailed ICD-9 procedure codes. There are 3,948 distinct

ICD-9 procedure codes, and we use the Clinical Classifications Software (CCS) for ICD-9-CM to map the procedure codes into broader service categories. The CCS is a diagnosis and procedure categorization scheme that is developed as part of the Healthcare Cost and Utilization Project. CCS collapses the ICD codes into a smaller number of clinically meaningful categories. We define the services at Level 2 of the multiple-level procedure categories. Level 2 classifies procedure codes into 207 distinct categories. We map all the procedures hospitals performed to these 207 services and analyze changes in hospitals' provision of these services. Additionally, CCS classifies the diagnosis codes, which serve as an alternative definition of service. We use CCS to map diagnosis codes from discharges to services and run robustness checks (described in Section 4.3.1).

2.3 California Hospital Financial Disclosure Reports

All California-licensed general acute hospitals are required to file detailed annual financial disclosure reports. The reports are audited and provides information about various aspects of hospital operations, including capacity, medical staff, utilization, ownership type, balance sheets, income statements, revenue, and expenses. For the medical staff, beds, utilization, and expenses, the reports provide detailed information by service categories. We use the comprehensive cost information from the financial data set to evaluate the cost change related to service consolidation by comparing the per-unit cost of consolidated and non-consolidated services. The per-unit service cost is defined as the adjusted direct expenses of each service category over the total units performed by the hospitals for that service.

2.4 American Hospital Association Annual Survey (AHA)

To test whether service repositioning differs across the targets and acquirers in merging health care systems, we expand the study to a national sample of hospitals. The sample size in the American Hospital Association (AHA) data is significantly larger than California, which enables us to study the targets and acquirers separately. We use the AHA Annual Survey to study the services provided by the hospitals. The AHA data set covers over 80% of all hospitals in the United States and contains general information such as ownership type, the total number of beds, and total discharges. Moreover, it contains the service provision for 120 services. We adopt these service indicators to determine the service offered by the hospitals and whether merging hospitals remove duplicate services. However, unlike the discharge data, the AHA data set does not contain information on service volume. It thus does not allow us to investigate whether service repositioning occurs in any form subtler than complete service removal.

2.5 Sample Construction

For our primary analysis, we use a sample similar to that of Gaynor, Kleiner and Vogt (2015) with the California data. We concentrate on general hospitals and exclude children's hospitals and hospitals specializing in psychiatric, chemical dependency, or long-term care. After data trimming, our sample contains 355 California hospitals. Based on the previous service definitions, the summary statistics of the California hospitals in the beginning year of the sample period (2002) are presented in Table 1.[6] The first three columns show the summary statistics of merging hospitals based on their distance to their merging counterparts, and the fourth column presents the statistics for the non-merging hospitals. The characteristics of hospitals that merge are similar across all three distance groups. However, the non-merging hospitals are different from the merging entities in some characteristics. The merging hospitals offer more services than the non-merging hospitals and are less concentrated in their service offerings than the non-merging hospitals. The merging hospitals also operate at lower total patient care costs than the non-merging hospitals, and they treat more complicated patients because they have a higher case-mix index.[7]

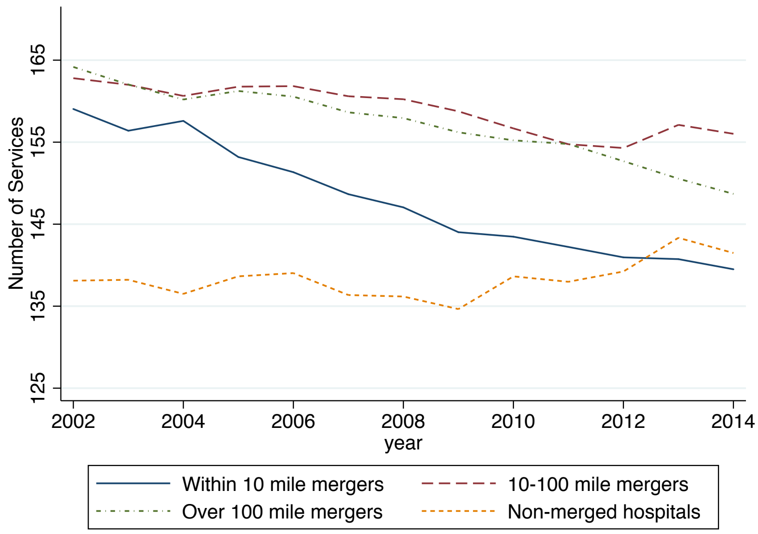


Figure 3: Number of Services over Time by Distance Group

[6]Hospital HHI across services in Table 1 is defined in Section 4.2.1.

[7]The case-mix index is the average relative diagnosis-related group weight of a hospital's inpatient discharges, calculated by summing the Medicare Severity-Diagnosis Related Group (MS-DRG) weight for each discharge and dividing the total by the number of discharges. The case-mix index reflects the diversity, clinical complexity, and resource needs of all the patients in the hospital. A higher case-mix index indicates a more complex and resource-intensive case load. Although the MS-DRG weights, provided by the Centers for Medicare and Medicaid Services, were designed for the Medicare population, they are applied here to all discharges regardless of payer.

Table 1: Summary Statistics of California OSHPD & Financial Data at Year 2002

	Merged <10 miles	Merged 10-100 miles	Merged >100 miles	Non-merged All
Number of services (by proc)	159.0	162.8	164.2	138.1
	(24.63)	(28.95)	(26.71)	(54.40)
Number of services (by diag)	130.0	131.9	132.8	125.7
	(5.866)	(4.588)	(4.892)	(15.92)
Hospital HHI across services (by proc)	1158.2	924.8	927.3	1647.9
	(592.0)	(688.7)	(428.1)	(1856.2)
Hospital HHI across services (by diag)	337.4	361.3	338.3	354.6
	(69.63)	(80.06)	(63.79)	(142.8)
Case-mix index	1.072	1.061	1.111	1.045
	(0.235)	(0.192)	(0.196)	(0.221)
Number of staffed beds	181.5	213.0	204.8	184.8
	(99.83)	(157.9)	(116.3)	(164.4)
Total discharges	8735.0	10875.0	9506.6	9018.6
	(5585.7)	(7038.1)	(5837.0)	(8762.1)
Board certified/eligible physicians	253.2	343.6	248.8	224.6
	(187.1)	(264.0)	(194.1)	(267.3)
Total discharge days (in thousand)	45.59	52.67	43.43	45.56
	(27.71)	(36.98)	(25.83)	(42.57)
Total patient care cost (in million)	95.50	129.4	107.0	123.8
	(70.75)	(102.3)	(66.28)	(161.1)
Number of Hospitals	41	60	64	190

Figure 3 depicts the change in the average number of services over time for non-merging hospitals and for merging hospitals from different distance groups. As shown, non-merging hospitals offer a stable number of services over time, and hospitals that merge offer fewer services over time. Merging hospitals that are within 10 miles of each other experience larger reductions in the number of services than do merging hospitals that are farther away from each other.

The summary statistics suggest two features of our data: first, merging hospitals are different from the non-merging hospitals on many dimensions, which suggests that there is selection into mergers. Second, there seems to be some systematic changes in service offering after mergers, especially for those involving geographically close hospitals. Both facts motivate our empirical design, which we detail in Section 4.

Figure 4: Illustrative Example of Service Consolidation with Service Removal

	OSF Anthony Medical Center	Rockford Memorial Hospital
Cardiovascular surgery	200	250
Trauma	300	200

	OSF Anthony Medical Center	Rockford Memorial Hospital
Cardiovascular surgery	0	430
Trauma	450	0

3 Conceptual Framework

An illustrative example of service consolidation is presented in Figure 4. The example refers to two hospitals in a previously mentioned antitrust case, OSF HealthCare and Rockford Health System. The OSF Medical Center and Rockford Memorial Hospital claimed they would consolidate their cardiovascular surgery and trauma services if the Federal Trade Commission cleared their proposed merger. The blue box on the left indicates the hospitals' service volumes before the merger, and the yellow box on the right provides the same information after the merger. One way these two hospitals might consolidate their cardiovascular surgery and trauma services is by eliminating cardiovascular surgery at OSF Anthony Medical Center, eliminating trauma care at Rockford Memorial Hospital, and steering patients for the eliminated service to the other hospital. In this scenario, both the cardiovascular surgery and trauma services are consolidated and provided by a single facility.

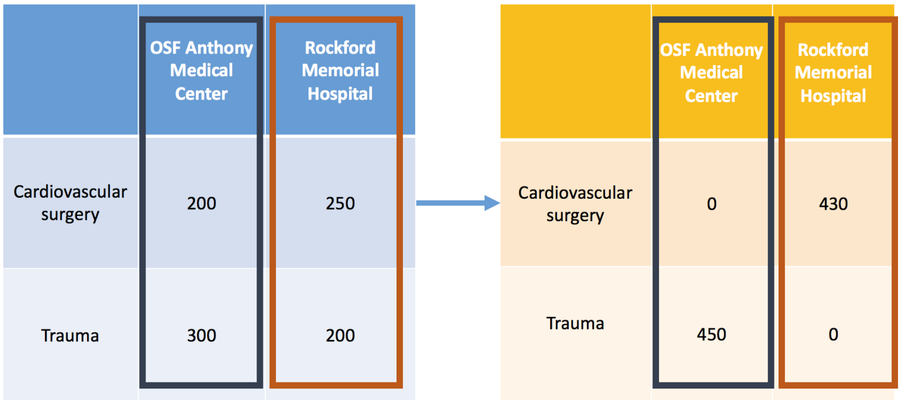
This type of consolidation has two effects—one on the total number of services offered by each hospital and the other on the number of duplicate services.

- Effect 1.a. (individual facility concentration): At the facility level, a merging hospital pursuing service consolidation decreases the number of services offered.

- Effect 2.a. (within-system differentiation): The service consolidation leads to fewer duplicate services across the merging hospitals.

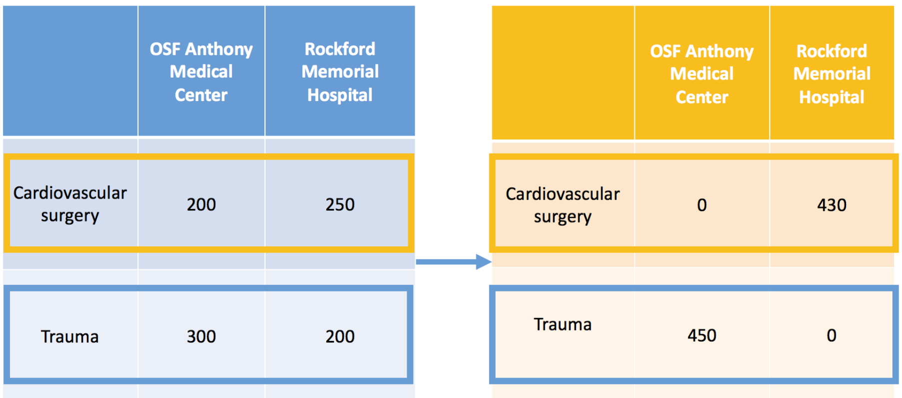
Effect 1.a stems from the phenomenon that each hospital participating in the service consolidation shifts some of its services to the other hospital. This repositioning leads to a decrease in the number of services the hospital offers. Figure 5 highlights this effect for the current example, showing that after the merger, the number of services offered by each hospital decreases from two to one. In other words, Effect 1.a reflects the fact that hospitals pursuing service consolidation become specialized and concentrated because they provide fewer services than they did before.

Figure 5: Illustration for Effect 1.a.



Meanwhile, Effect 2.a captures the idea that service consolidation shifts the services previously spread between two facilities into a single location. Figure 6 highlights the same two hospitals' service information horizontally. In this example, cardiovascular surgery and trauma care are provided by both hospitals before the merger but are available at only one facility after the merger. The merging pair therefore becomes more differentiated in terms of the services each provides.

Figure 6: Illustration for Effect 2.a.



These two effects depict two dimensions of service consolidation. If merging hospitals remove services but mainly remove their unique services, then Effect 1.a still holds, but Effect 2.a does not exist. On the other hand, if a merging hospital replaces duplicate services with new services that the other hospital does not provide, then we would observe Effect 2.a but not Effect 1.a. Our assessment of service consolidation will examine both of these effects by looking at changes in the number of services provided by each facility as well as the number of duplicate services available across facilities.

However, because the services we defined are based on aggregated procedure categories, analyses using the number of services neglect the service changes happening at the subcategory level. Moreover, while it may be organizationally difficult to remove or relocate a service entirely, hospitals might try to consolidate services in more subtle ways by redirecting patient flows to concentrate volume at one facility. An example of service consolidation through patient volume reallocation rather than service removal is illustrated in Figure 7. Here, OSF Anthony Medical Center keeps some cardiovascular surgery services (e.g., Maze surgery), but moves most of these services to Rockford Memorial Hospital. Both hospitals keep cardiovascular surgery, but the volume is highly concentrated in one facility. This type of service consolidation can be described by two effects:

- Effect 1.b. (individual facility concentration of service volume): At the facility level, a merging hospital pursuing service consolidation by reallocating patient volume experiences an increase in the concentration of volumes across services.
- Effect 2.b. (within-system differentiation of service volume): Relocation of a given service concentrates patient volumes in a single facility, increasing the volume HHI across hospitals for that consolidated service.

Effects 1.b and 2.b follow the same intuition as Effects 1.a and 2.a, but the measurement of consolidation refers to the volume of services rather than the number of services. There are two main benefits of using service volume as a measure of service offering. First, volume captures the change in services in the absence of complete removal of duplicate services. Second, studying the service volume enables us to evaluate the magnitude of service repositioning from the utilization perspective. If the consolidated services are mainly low-volume services, they will not significantly impact the service volume concentration across services. Therefore, the service volume analysis supplements the number of services results by quantifying the impact on utilization.

However, even if a hospital drops duplicate services, the new system under a merger might shift its service spectrum for the whole system and remove some services in every facility. This strategy leads to removal of services from both members of a merging pair – in contrast to service consolidation, which results in removal from one hospital but keeping the service in the other. To determine which mechanism drives the change in hospital services, we analyze the

Figure 7: Illustrative Example of Consolidation without Service Removal

	OSF Anthony Medical Center	Rockford Memorial Hospital
Cardiovascular surgery	200	250
Trauma	300	200

	OSF Anthony Medical Center	Rockford Memorial Hospital
Cardiovascular surgery	30	400
Trauma	400	60

number of services and the service concentration of the hospital pairs.

Finally, we study the heterogeneous effect of mergers across different geographic distances.[8] Service consolidation is feasible only if the merging hospitals are geographically close. If two hospital facilities are distant from each other, it is not realistic to consolidate the service volume of a given service into a single location, because patients are sensitive to travel distance.[9] Thus, we separately examine merger effects on service consolidation for different distance groups.

4 Empirical Analysis on Service Repositioning Pattern

4.1 Number of Services

4.1.1 Effect 1.a: Individual Facility Concentration

We use the following staggering difference-in-differences model to quantify Effect 1.a:

$$n_{it} = \alpha_i + \gamma_t + \lambda \cdot \mathbb{1}[t \geq \tau_i] + \epsilon_{it}, \tag{1}$$

where n_{it} denotes the number of services provided by hospital i in year t. α_i denotes hospital fixed effects, γ_t is the year fixed effect included to absorb any time trend. $\mathbb{1}[t \geq \tau_i]$ is a binary variable indicating whether hospital i at year t is in or later than the treatment year τ_i. λ represents the treatment effect, indicating the change in the number of services relative to the control group.

[8]We demonstrate that distance is important in deciding whether to remove a service using a theoretical model that is presented in the Appendix.

[9]For instance, Gowrisankaran, Nevo and Town (2015) find that a five-minute increase in travel time to a hospital reduces demand between 17% and 41%.

The baseline analysis includes only merging hospitals with counterparts within 100 miles and excludes all non-merging hospitals. This avoids the potential bias in a comparison of merging and non-merging hospitals since there is likely selection into merger activity in this market. We also exclude mergers of hospitals that are farther than 100 miles from each other, because geographically close mergers may be different from distant, out-of-market mergers.

Because service consolidation is sensitive to the distance between the merging hospitals, we specify two distance groups: one whose merging counterparts are no farther than 10 miles apart, and another where the merging hospitals are between 10 and 100 miles away from each other. This procedure is captured in Equation (2), where λ_g is the post-merger effect of the hospital i belonging to the distance group $\mathcal{G}_g \in \{\mathcal{G}_1, \mathcal{G}_2\}$, $\mathcal{G}_1$ stands for the hospitals with merging counterparts up to 10 miles away, and $\mathcal{G}_2$ represents those with merging counterparts 10 to 100 miles away.

$$n_{it} = \alpha_i + \gamma_t + \sum_g \lambda_g \cdot \mathbb{1}[t \geq \tau_i] \times \mathbb{1}[i \in \mathcal{G}_g] + \epsilon_{it}. \tag{2}$$

Additionally, to fully understand the evolution of service repositioning after mergers, we conduct an event study to decompose the effect of mergers on consolidation over time as follows:

$$n_{it} = \alpha_i + \gamma_t + \sum_{k=-5}^{3} \lambda_{k1} \cdot \mathbb{1}[t = \tau_i + k] \times \mathbb{1}[i \in \mathcal{G}_1] + \sum_{k=-5}^{3} \lambda_{k2} \cdot \mathbb{1}[t = \tau_i + k] \times \mathbb{1}[i \in \mathcal{G}_2] + \epsilon_{it}. \tag{3}$$

We group observations that are five or more years prior to the merger into $k = -5$, and $k = 3$ indicates three or more years after the merger. λ_{kg} represents the effect on service repositioning of being k years post-merger for group $\mathcal{G}_g$.

4.1.2 Effect 2.a.: Within-System Differentiation

We analyze the number of duplicate services of merged hospitals to measure Effect 2.a. The number of duplicate services is obtained by counting the number of services offered by both hospitals in a merged pair. Specifically, we estimate the following equation:

$$d_{pt} = \alpha_p + \gamma_t + \sum_g \lambda_g \cdot \mathbb{1}[p \in \mathcal{G}_g, t \geq \tau_p] + \epsilon_{pt}, \tag{4}$$

where p is the index for the hospital pair, and d_{pt} indicates the number of duplicate services for the hospital pair p at time t. $\mathcal{G}_g$ indicates that the merging pair falls into different distance group g, where $\mathcal{M}_g \in \{0 - 10 \text{ miles}, 10 - 100 \text{ miles}\}$. τ_p represents the merger time of hospital pair p, and $\mathbb{1}[p \in \mathcal{G}, t \geq \tau_p]$ indicates the post-merger status of hospital pair p. λ_g is the post-merger change in duplicate services among hospital pairs in group g. This heterogeneous effect parameter allows us to evaluate how the post-merger duplication change varies with distance between the merging hospitals. In addition to this specification, we replace the dependent variable in Equation (4) with the total number of services of the hospital pairs. The total number of services of hospital pairs enables us to determine whether the services are dropped for consolidation at one facility and kept at the adjacent facility or the services are entirely removed at both hospitals.

Identification Our baseline models exclude non-merging hospitals in the sample. The merging decision is likely endogenous and is related to many other factors involved in repositioning decisions. This phenomenon can be illustrated by the summary statistics shown in Table 1. As such, the non-merging hospitals may not be comparable to the merging hospitals. To address this concern, we include only merging hospitals. Our specification uses the variation in the timing of mergers: hospitals that merged later serve as the controls for hospitals that merged earlier, and the time trend is jointly determined by all the merging hospitals. Our model assumes a parallel pretrend across hospitals that merged earlier and those that merged later. The selection of merging time may undermine this assumption. However, due to the complexity of merger activity and the involvement of antitrust authorities, hospitals have little control over when a merger will be approved, which mitigates the concern about selection based on merger time. Section 1.2 of the Appendix provides evidence on the internal validity of this method by showing that there is no correlation between the time of the merger and the change in hospitals' service offerings.

4.1.3 Results

Number of Services of Individual Hospitals Table 2 presents the change in the number of services based on procedures performed after a merger. The regression sample is composed of merging hospitals with a counterpart within 100 miles. Columns (1) and (2) use individual hospitals' number of services as the dependent variable. The merging hospitals that are within 100 miles of each other experience a slight drop of about 1.2 services on average after the merger. This effect is mainly driven by the service change of merging hospitals that are closer to each other. Merging hospitals that are within 10 miles of each other experience a drop of approximately 4.5 services among all the services they offered. When we add the interaction term between post-merger status and the distance between the merging entities and their closest counterparts, we find that hospitals are less likely to drop services as the distance between them increases. This finding also holds when hospitals are grouped into narrower distance groups (see Table 17 in the Appendix).

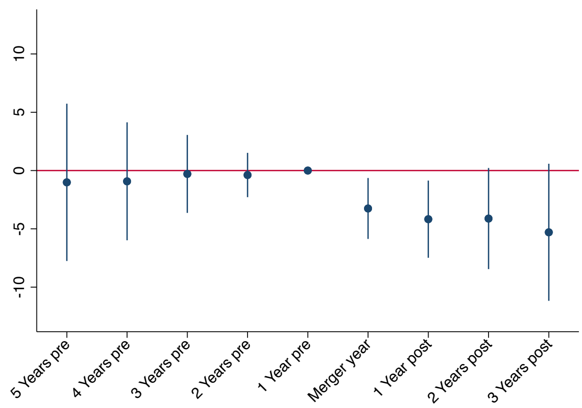
Table 2: Post Merger Effect of Individual Hospital of Mergers within 100 miles

	(1) Number of Services	(2) Number of Services	(3) Number of Services
Post merger	-1.248		-4.498*
	(1.942)		(2.411)
Post merger 0-10 miles		-4.531*	
		(2.357)	
Post merger 10-100 miles		2.120	
		(2.365)	
Post merger × Merger distance			0.211***
			(0.068)
N	1208	1208	1208
R^2	0.95	0.95	0.95

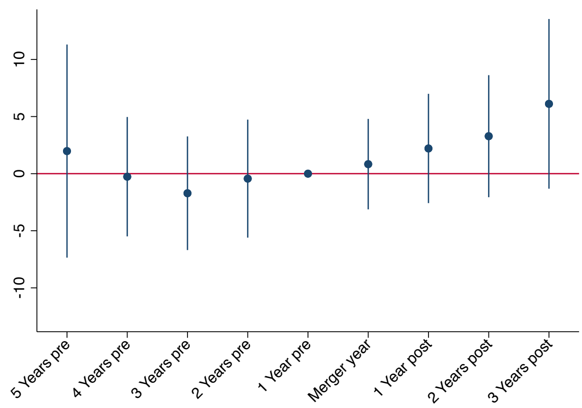
Model clusters at individual hospital level.[10] Total number of beds and for-profit status of hospitals are included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Figure 8 shows the results of the event study. The parallel trend assumption holds for the analysis with the total number of services, and there is a lasting post-merger service decrease for merging hospitals with a counterpart within 10 miles. Merging hospitals that are farther apart exhibit no such effect.

Figure 8: Event Study of Number of Services



(a) Merged in 0-10 miles



(b) Merged in 10-100 miles

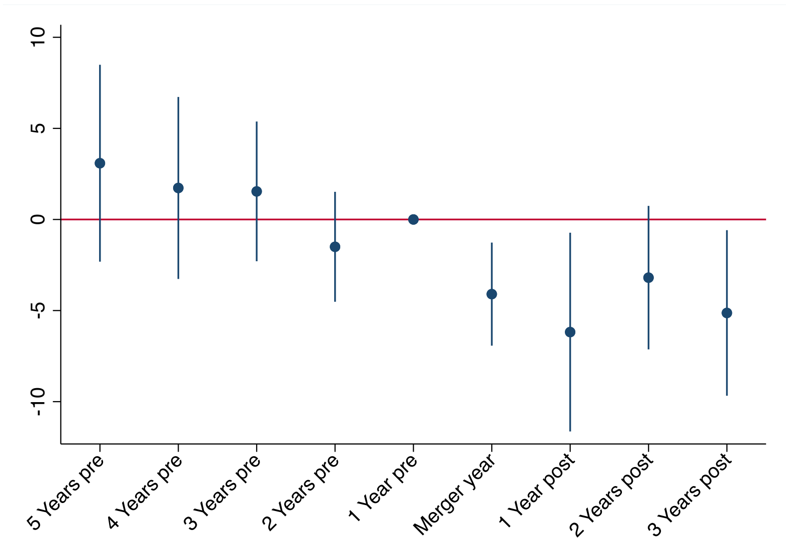
Number of Services of Hospital Pairs The analysis with the merging hospital pairs within 100 miles of each other is presented in Table 3. For all the merging hospital pairs within 100 miles, the nearby merging hospitals remove 5.1 duplicate services on average. This decrease in

Table 3: Post Merger Effect of Merged Pairs within 100 miles

	(1) Duplicate Services	(2) Total Services
Post merger 0-10 miles	-5.147***	-0.889
	(1.705)	(1.130)
Post merger 10-100 miles	-1.821	-0.209
	(1.443)	(0.846)
N	1475	1475
R^2	0.93	0.92
$DependentMean$	131.43	177.40
$DependentS.D.$	27.16	14.76

Model clusters at hospital pair level. Total number of beds is included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Figure 9: Event Study of Duplicate Services of Merging Pairs within 10 miles



the number of services is mainly due to service consolidation rather than service elimination, because the total number of services by the merging hospital pairs that are within 10 miles of each other does not decrease significantly. The event study of the number of duplicate services of hospital pairs within 10 miles of each other is presented in Figure 9. The effect of the number of duplicate services starts to show up in the merger year and persists several years after the merger.

4.2 Service Volume

4.2.1 Effect 1.b: Individual Facility Concentration of Service Volume

To test Effect 1.b, we adopt a similar specification as in Equation (1) by replacing the dependent variable with the hospital's volume HHI across services to measure the concentration of volume across services. The volume HHI across services is defined as follows:

$$HHI_{it} = \sum_{s} \left(\frac{v_{sit}}{\sum_{s}^{S} v_{sit}}\right)^2 \times 10000, \tag{5}$$

where for each individual hospital i, v_{sit} is the volume of service $s \in \{1, 2, ...S\}$ at time t, and HHI_{it} measures the concentration across service. The DID specification we use is as follows:

$$log(HHI_{it}) = \alpha_i + \gamma_t + \eta \cdot \mathbb{1}[t \geq \tau_h] + \epsilon_{it}. \tag{6}$$

We continue to use 100 miles as the distance for our baseline merger sample. Meanwhile, we also aim to understand how the effect varies with the distance of hospitals. Therefore, we decompose in the following equation the effect by the two distance groups, 0–10 miles and 10–100 miles:

$$log(HHI_{it}) = \alpha_i + \gamma_t + \sum_{g} \eta_g \cdot \mathbb{1}[i \in \mathcal{G}_g, t \geq \tau_i] + \epsilon_{it}, \tag{7}$$

where $\mathcal{G}_g$ indicates merging hospitals in group $\mathcal{G}_g \in \{\mathcal{G}_1, \mathcal{G}_2\}$, and η_g represents the change in HHI of group $\mathcal{G}_g$ after the merger. As before, we run the event study to separately decompose the time varying effect with the mergers in different distance group.

4.2.2 Effect 2.b: Within-System Differentiation of Service Volume

Specification To study the post-merger change of hospital pair HHI across services, we calculate

$$HHI_{pt} = \sum_{s} \left(\frac{v_{spt}}{\sum_{s}^{S} v_{spt}}\right)^2 \times 10000, \tag{8}$$

where v_{spt} is the volume of the hospital pair p in service s at time t. The specification used to study this change is

$$log(HHI_{pt}) = \alpha_p + \gamma_t + \sum_{g} \zeta_g \cdot \mathbb{1}[p \in \mathcal{G}_g, t \geq \tau_p] + \epsilon_{pt}, \tag{9}$$

where ζ_g represents the change of the hospital pair's HHI across services after the merger if the merging pair belongs to distance group g. Again, we only include merging pairs that are within 100 miles of each other. Observing a significant treatment effect in this specification indicates that, at the system level, some services are reduced or even eliminated, and this could be the reason for the individual facility's concentration change in the testing of Effect 1.b. On the other hand, if no significant increase in the hospital pair's HHI across services is found, then at the system level there is no significant change of service composition, which would confirm that the service repositioning is a shift of services across locations rather than a system-level service reduction.

Additionally, we analyze the pair HHI of each service separately to examine Effect 2.b. For a given service s, the pair HHI of that given service is defined as follows:

$$HHI_{spt} = (\frac{v_{sit}}{v_{sit} + v_{sjt}})^2 + (\frac{v_{sjt}}{v_{sit} + v_{sjt}})^2, \tag{10}$$

where hospital i and j are the two hospitals composing hospital pair p.

We estimate the following equation service by service to examine the change of service volume distribution across facilities:

$$log(HHI_{spt}) = \alpha_{sp} + \gamma_t + \sum_g \eta_g \cdot \mathbb{1}[p \in \mathcal{G}_g, t \geq \tau_p] + \epsilon_{pt}, \tag{11}$$

where α_{sp} are the pair-service fixed effects, and η_g represents the post-merger change of the HHI of the hospital pair in distance group g in service s. Similar to before, we use only merging hospitals with a counterpart within 100 miles to avoid possible selection bias in the comparison of merging and non-merging pairs. We estimate the equation at three different service levels: using all services; separately by service categorization (Level 1 of CCS); and separately for each service.

4.2.3 Empirical Results

Service Volume of Individual Hospitals Table 4 shows the results with hospital pairs. In columns (1) and (2), the dependent variable is the log HHI of individual hospitals across all services offered. On average, there exists a 5.4% increase in HHI across services for all merging hospitals with a counterpart that is within 100 miles. When we decompose the effect for mergers with different distance groups, the increase of HHI is mainly driven by mergers of hospitals that are geographically close (within 10 miles). These hospitals experience a 10.7% increase in the

HHI across all the services. Meanwhile, the geographically distant merging hospitals do not exhibit a significant change in the HHI.

In Table 4 column (3) and (4), we change the dependent variable to the log of HHI of individual hospitals computed using only the services that remain in place after a merger. While columns (1) and (2) include information on both service removal and patient reshuffling, columns (3) and (4) provide the service volume change only for the services kept after a merger. For all the merging hospitals with a counterpart within 100 miles, there exists a 4.6% increase in HHI of non-removed services. The effect is particularly strong for the nearby merging hospitals (within 10 miles), as they have a 8.7% increase in the non-removed services. Therefore, for the services that are not removed, there is still some repositioning in terms of the service volume reshuffle, and hospitals become more concentrated in the procedures they perform.

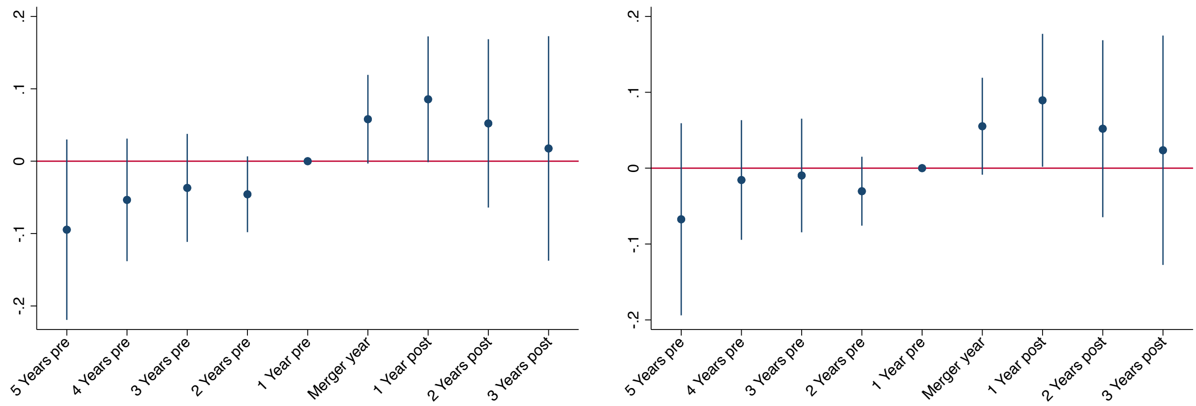
Table 4: Post Merger Effect of Individual Hospital of Mergers within 100 miles

	(1) Log HHI of All Services	(2) Log HHI of All Services	(3) Log HHI of Non-removed Srv	(4) Log HHI of Non-removed Srv
Post merger	0.054		0.046	
	(0.032)		(0.032)	
Post merger 0-10mile		0.102**		0.087*
		(0.050)		(0.049)
Post merger 10-100mile		-0.007		-0.007
		(0.037)		(0.037)
N	1208	1208	1208	1208
R^2	0.89	0.89	0.90	0.90

Model clusters at individual hospital level. Total number of beds and for-profit status of hospitals are included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Figure 10 presents the change of the log HHI of services over time. Panel (a) uses the specification in Table 4 column (2) while Panel (b) adopts the specification in Table 4 column (4). The event study figures show that the HHIs based on all services and non-removed services both increase after a merger by about 10%, meaning that the individual hospitals become more concentrated on service provision, even for services that are not entirely removed. Note that both panels exhibit a one-year pre-trend in which the increase of HHI starts one year before the merger. One potential reason for this is that mergers take a while to complete. Due to the complexity of merger deals and other regulatory factors, there is usually a time gap between when a merger starts and when it is completed. The merger activity database we use provides the complete time of the mergers. Any repositioning activity that happens after the merger starts but before the merger is complete could result in a change of service repositioning before the merging time.

Figure 10: Event Study of Log HHI of Services for Hospitals with Group 0-10 miles



(a) Log HHI of All Services

(b) Log HHI of Non-removed Services

Service Volume of Hospital Pairs The increase of service concentration within a facility could be driven either by patients moving across facilities or by services being reduced at the system level. To determine which force dominates, we analyze the change of service concentration at the hospital pair level. As shown in Table 5, there is no significant change in service concentration, indicating that systems are moving patients around and concentrating similar patients in a single facility after mergers rather than reducing service capacity.

Table 5: Post Merger Effect of Log HHI of Merged Pairs within 100 miles

	(1) Log HHI of Services
Post merger 0-10 mile	-0.011
	(0.049)
Post merger 10-100 mile	0.026
	(0.033)
N	1475
R^2	0.88
$DependentMean$	-2.63
$DependentS.D.$	0.48

Model clusters at hospital pair level. Total number of beds is included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Service-by-Service Analysis To identify which services are consolidated, we run a service-by-service analysis using Equation (11). The dependent variable is the HHI for each service pair. The results are summarized in Table 6. The first four columns of the table contain the estimated coefficients and standard errors using Equation (11) by service categories (CCS Level 1). The last two columns present the number of services in the specific service categories and

Table 6: Summary of Service by Service Analysis

Level 1 Service Category	post 0-10 miles	se	post 10-100 miles	se	Num. of Services	Significant Service Num
Obstetrical procedures	0.050**	(0.021)	0.007	(0.013)	10	6
Op. on female genital organs	0.049***	(0.016)	0.022**	(0.010)	13	4
Op. on cardiovascular system	0.039**	(0.016)	-0.004	(0.010)	21	7
Op. on endocrine system	0.034	(0.020)	0.025	(0.019)	3	1
Op. on nervous system	0.032**	(0.015)	0.001	(0.010)	9	3
Op. on hemic & lymphatic system	0.032**	(0.012)	0.016	(0.024)	4	1
Op. on respiratory system	0.025	(0.021)	-0.0034	(0.012)	9	0
Op. on nose; mouth; and pharynx	0.020	(0.020)	0.013	(0.011)	7	1
Misc diag/therapeutic proc	0.011	(0.009)	-0.0068	(0.0070)	42	5
Op. on integumentary system	0.011	(0.012)	0.0010	(0.015)	9	0
Op. on digestive system	0.006	(0.010)	-0.009	(0.009)	31	0
Op. on urinary system	0.001	(0.013)	-0.0003	(0.011)	11	1
Op. on musculoskeletal system	0.0007	(0.017)	-0.021	(0.021)	17	3
Op. on eye	-0.027	(0.024)	-0.0072	(0.020)	9	0
Op. on ear	-0.016	(0.020)	0.019	(0.019)	5	0
Op. on male genital organs	-0.009	(0.014)	0.007	(0.016)	6	0
All Services	0.017	(.011)	-0.002	(0.009)	204	32

[1] We abbreviate "Operations" as "Op.". The last two columns present how many services belong to that specific service category (Num. of Services) and how many of these services have observed significant increase in concentration when we run the analysis service by service (Significant Service Num.).
[2] The estimated coefficients and standard erros in the second to the fifth column are from analyses using only the services belonging to the correpsonding service category in the first column.
[3] Model clusters at hospital pair level. Total number of beds is included in regressions. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

the number of these services that have a significant increase in concentration. For instance, for all services in the category of obstetrical procedures, on average there is a 5% increase in pair HHI for merging hospitals that are within 10 miles of each other and a 0.7% increase for merging hospitals that are between 10 and 100 miles away from each other. Ten services fall into this category, and six of them have a significant increase (at the 10% significance level) in their pair HHI for the within-10-mile mergers.

Services that are most often consolidated are obstetrical procedures, operations on female genital organs, and cardiovascular surgeries.[11] The last row of Table 6 presents the regression

[11] These services are consistent with the claimed services to be consolidated by the CEO of OSF HealthCare when the proposed merger is challenged by the Federal Trade Commission.

result when all services are included in Equation (11). When all services are pooled together, there is a minor effect of a 1.7% increase in services' pair HHI. This effect is not significant because we average the consolidation occurring only in a subset of services to all services and dissipate the effect.

4.3 Robustness Check

4.3.1 Alternative Definition of Hospital Services Using Diagnoses

Instead of defining services by the procedure codes, we can define services using diagnosis information. Diagnoses contain information related to patients' symptoms and diseases, while procedures specify the treatment patients receive. To determine whether evidence exists of service repositioning regarding the diseases hospitals cover, we use the ICD-9 diagnosis codes from the California Patient Discharge Data to build an alternative service measurement. As in our earlier analysis, we classify the large number of ICD-9 diagnosis codes using the CCS and define a service at Level 2 of the multilevel diagnosis categories.

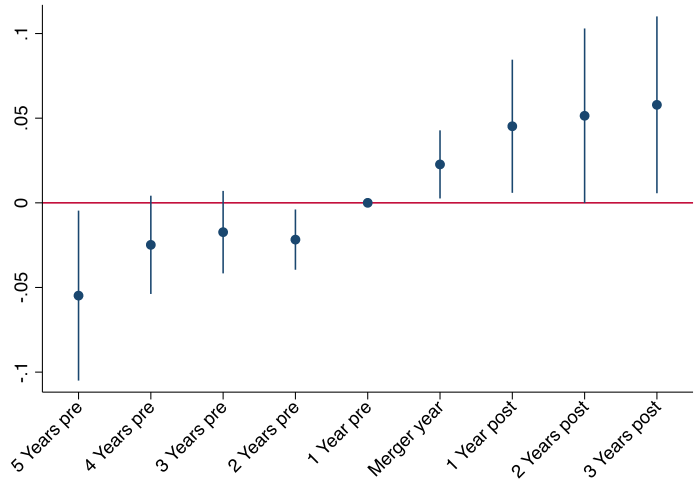
Table 7: Post Merger Effect of Services by Diagnosis of Merged Hospitals within 100 miles

	(1) Number of Srv.	(2) Number of Srv.	(3) Log HHI of Srv.	(4) Log HHI of Srv.
Post merger	-0.911		0.041*	
	(0.861)		(0.023)	
Post merger 0-10 miles		-0.662		0.067***
		(0.477)		(0.019)
Post merger 10-100 miles		-1.280		0.011
		(1.592)		(0.039)
N	1208	1208	1208	1208
R^2	0.78	0.78	0.80	0.80

Services are defined by diagnosis classification. Model clusters at hospital pair level. Total number of beds and for-profit status are included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

We implement the analysis of service numbers and volume HHI at the individual hospital level using services defined by the diagnoses. Table 7 presents the results. As shown in columns (1) and (2), there is no significant change in the effect on the number of services by diagnoses. However, as shown in columns (3) and (4), individual hospitals become more concentrated in terms of the diagnoses they treat. The results indicate that hospitals may not be able to entirely refuse patients with certain symptoms and diseases, but they possess some ability to steer patients into different facilities after mergers based on patients' diagnoses. Figure 11 shows the event study of column (4). A one-year pre-trend exists, as it does in Figure 10. This pattern could be driven either by the time gap between when a merger process begins and ends, or by

Figure 11: Event Study of Log HHI of Services by Diagnoses of within-10-mile Merging Hospitals



some merging hospitals repositioning early because of poor financial conditions.

4.3.2 Matched Non-merging Hospitals as Control

To check the robustness of our main results, we use the matching DID to estimate the change between the within-10-mile merging hospitals and the nonmerging control hospitals. Specifically, we use propensity score matching to build the control group with a similar service concentration and capacity as the within-10-mile merging hospitals. Similar to Heckman et al. (1998) and Smith and Todd (2005), we match on the pre-treatment history of an outcome variable, log HHI of services, and total beds. We drop merging hospitals that lack a corresponding control.[12] Table 8 shows the summary statistics of the matched sample in the beginning year (2002). Overall, the matched sample is balanced, with no significant group mean difference across the treatments and controls.

The estimated postmerger effects are robust using matched nonmerging hospitals as controls. As shown in Table 9 column (1), merging hospitals that are within 10 miles of each other drop about six services compared to the matched nonmerging hospitals. In the same table, columns (2) and (3) indicate that the HHI of services (defined by procedures) increases around 11%–12%, regardless of whether the dropped services are excluded. Columns (4) and (5) define the services by the diagnosis as in the previous robustness check. There is no significant drop in number of services, but the HHI of services defined based on diagnosis increases by 3.3%.

Figure 12 presents an event study of the within-10-mile merging hospitals and the matched control group (i.e., the event study for column (2) and (3) in Table 9). The one-year pre-

[12]We set a caliper of 0.08 in the matching exercise.

Table 8: Summary Statistics of California OSHPD & Financial Data of the Matched Sample, 2002

Number of services (by proc)	160.5	155
	(24.44)	(39.46)
Number of services (by diag)	130.2	130.2
	(5.691)	(13.12)
Hospital HHI of services (by proc)	1151.6	1083.4
	(564.5)	(696.4)
Hospital HHI of services (by diag)	336.7	333.7
	(66.58)	(70.68)
Casemix index	1.099	1.010
	(0.247)	(0.139)
Number of staffed beds	182.8	169.5
	(85.30)	(111.5)
Total discharges	8616.7	9191.5
	(4439.5)	(7044.1)
Board certified/eligible physicians	245.8	224.6
	(154.5)	(227.0)
Total discharge days (in thousand)	46.55	40.93
	(24.44)	(27.94)
Total patient care cost (in million)	94.78	105.1
	(65.82)	(83.69)
Number of Hospitals	34	29

Match is implemented with replacement.

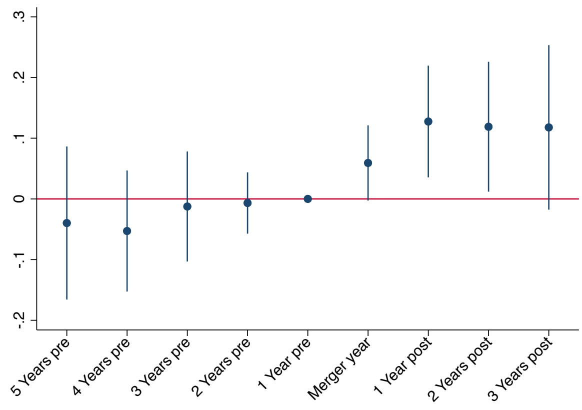
Table 9: Within-10mile Merged Hospitals Compared with Matched Non-merged Controls

	(1) Number of Services by Proc	(2) Log HHI of All Services by Proc	(3) Log HHI of Non-removed Services by proc	(4) Number of Services by Diag	(5) Log HHI of All Services by Diag
Post merger	-6.085***	0.120**	0.113**	-0.393	0.033*
	(1.937)	(0.055)	(0.054)	(0.255)	(0.019)
N	759	759	759	759	759
R^2	0.95	0.88	0.88	0.93	0.83

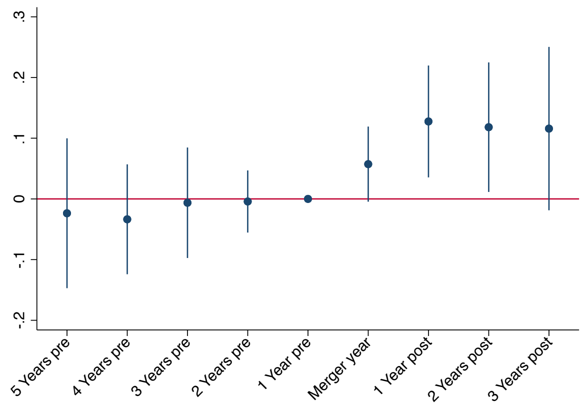
Model clusters at hospital level. Total number of beds and for-profit status of hospitals are included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

trend displayed in Figure 10 disappears in this matching-DID specification, indicating that our matching process selects a control group of similar pre-merger outcomes as the treatments. The parallel trend assumption also holds for other outcome variables. We present the results in the Appendix.

Figure 12: Event Study of 10-mile Merging Hospitals and Matched Non-merging Controls



(a) Log HHI of All Services



(b) Log HHI of Non-removed Services

4.3.3 Other Measurement of Hospital Repositioning

The California Hospital Financial Reports also include information on numbers of physicians, beds, discharges, and discharge days at the service category level. We construct measures on service concentration based on these variables and use them to examine service repositioning after a merger.

Table 10: Other Measurements of Service Concentration of Merged Hospitals within 100 miles

	(1)	(2)	(3)	(4)
	Log HHI of Physicians	Log HHI of Beds	Log HHI of t days Patient days	Log HHI of Discharges
Post merger of 0-10mile	-0.043***	0.100***	0.077**	0.078**
	(0.014)	(0.036)	(0.034)	(0.034)
Post merger of 10-100 miles	-0.033	0.015	0.011	0.022
	(0.021)	(0.058)	(0.052)	(0.057)
N	1113	1208	1208	1208
R^2	0.78	0.87	0.89	0.83

Models are clustered at individual hospital level. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Table 10 presents the results. The dependent variable of column (1) is the log HHI of physicians across different service categories, and the dependent variable of column (2) is the log HHI of beds by service categories. The dependent variables of columns (3) and (4) are log HHI derived from total patient days and discharges of different service categories. All measurements except those for physicians indicate that services become more concentrated after a merger. This effect does not hold for physicians, perhaps because most physicians are not directly hired by hospitals and are able to freely choose at which hospital they treat their patients.

4.3.4 Analysis with Target and Acquirer using AHA Data

One may wonder whether service repositioning is mainly driven by the targets or the acquirers in a merger. It is possible that acquirers absorb all the services offered by targets, and thus only targets drop services. Alternatively, both facilities might drop (different) services at the same time. Since our baseline sample of California hospitals is not large enough to separately examine the treatment effects for targets and acquirers, we use AHA data to explore this issue. The AHA data include all US hospitals. Details of the sample and service measure construction are provided in the Appendix.

Our main results hold in the national sample; that is, merging hospitals that are within 10 miles of each other are significantly more likely to remove duplicate services. We also find that both targets and acquirers experience service reduction after a merger, though the magnitude of the service reduction is slightly smaller for acquirers than targets. Details of the results are presented in the Appendix.

5 Implications for Service Cost and Quality

5.1 Provider Cost Change

Having established that geographically close hospitals tend to consolidate their services after a merger, we now examine whether service repositioning reduces hospitals' reported costs. We employ a difference-in-differences study design to compare the operating cost per procedure for consolidated and non-consolidated services.

5.1.1 Specification

Similar to the analysis with hospital pairs to identify service-specific HHI change, we use only the merging hospital pairs and compare the post-merger cost saving between consolidated and non-consolidated services:

$$log(c_{pst}) = \alpha_{ps} + \gamma_t + \lambda \cdot \mathbb{1}[t \geq \tau_p] + \delta \cdot \mathbb{1}[s \in \mathcal{S}, t \geq \tau_p] + \epsilon_{pt}, \tag{12}$$

where c_{pst} is the per-unit patient care cost for the hospital pair p's service s at time t, $\mathbb{1}[t \geq \tau_p]$ is the indicator of the post-merger status, and $\mathbb{1}[s \in \mathcal{S}, t \geq \tau_p]$ represents the post-merger status for consolidated services.[13] The parameter λ represents the average change of services pre- and post-merger, while δ indicates the extra cost change for the consolidated services compared with non-consolidated services. This δ term is identified through the comparison of consolidated and non-consolidated services. Under the assumption that the other merger-related factors that influence the standardized patient care cost per unit are similar across services, the difference between the consolidated and non-consolidated costs would be the extra cost related to consolidation in the repositioned services.

To address the concern that consolidated services and non-consolidated services are not comparable, we take advantage of the fact that service consolidation occurs only when merging entities are located close to each other, and we compare the cost change of the consolidated services across different merger distances. Specifically, we calculate

$$log(c_{pst}) = \alpha_{ps} + \gamma_t + \sum_g \eta_g \cdot \mathbb{1}[t \geq \tau_p] \times \mathbb{1}[p \in \mathcal{G}_g] + \epsilon_{pt}, \tag{13}$$

where η_g is the post-merger standardized cost change when a hospital pair p belongs to the distance group $\mathcal{G}_g \in \{$0-10 miles, 10-100 miles$\}$. Equation (13) is implemented on the sample consolidated and non-consolidated services separately.

5.1.2 Empirical Results

Table 11 presents the results of the cost analysis. Columns (1) and (2) include the sample of services of all merging hospital pairs within 100 miles. As shown in column (1), on average, there is an insignificant decrease in the per-unit patient cost of services after a merger. However, when comparing the consolidated and non-consolidated services (see column (2)), the cost of consolidated services decreases by 15.1%. When we restrict the sample to merging hospital pairs that are within 10 miles of each other, the difference is significantly larger: the consolidated services on average reduce the per-unit service cost by 31.1%. This result suggests that adjacent merging hospitals achieve most cost savings in consolidated services.[14]

Table 12 presents the cost per service unit for consolidated and non-consolidated services.

[13]Based on our analysis before, consolidated services are cardiovascular system and obstetrical procedures.

[14]Schmitt (2017) finds that cost reductions are mainly driven by out-of-market mergers. However, the market definition in that paper is larger than our distance groups (larger than 100 miles), so we concentrate on different merger sample. Our findings that geographically-close mergers experience cost reductions through service consolidation is consistent with the findings by Craig, Grennan and Swanson (2018), who also find that cost savings are mainly driven by local mergers.

Table 11: Normalized Cost per Service Unit of Merged Hospital Pairs within 100 miles

	(1) 100-mile Merged	(2) 100-mile Merged	(3) 10-mile Merged
Post merger	-0.004	0.016	0.045
	(0.017)	(0.018)	(0.040)
Post merger × Consolidated Service		-0.151***	-0.311***
		(0.033)	(0.073)
N	37692	37692	8046
R^2	0.93	0.93	0.94

Model clusters at hospital level. Year fixed effects and Hospital× Service fixed effects are included. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

For the consolidated services, only the merging hospital pairs that are close to each other experience a significant drop in the service cost, because they are the hospitals effectively repositioning the consolidated services. The merging hospital pairs that are within 10 miles of each other experience a drop in cost of 19.9%, equivalent to approximately $277 for cardiac catheterization and $13 for echocardiology service. For the non-consolidated services, no statistically significant standardized cost differences are found for merging hospital pairs regardless of their distance from each other. The event study of column (1) in Table 12 is presented in Figure 13. The figure shows that consolidated services create long-term cost savings for merging hospitals that are close to each other.

Table 12: Normalized Cost per Service Unit of Merged Hospital Pairs by Distance

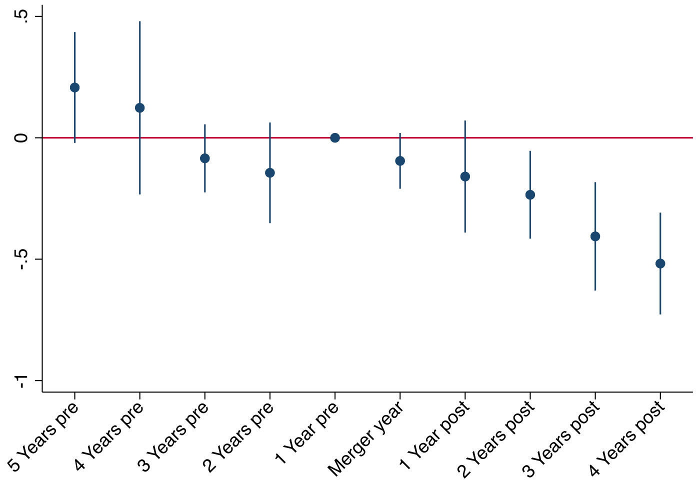
	(1) Consolidated Services	(2) Non-consolidated Services
Post merger 0-10 miles	-0.199***	0.013
	(0.066)	(0.038)
Post merger 10-100 miles	0.008	-0.005
	(0.035)	(0.018)
N	6025	31659
R^2	0.92	0.93

Model clusters at hospital level. Year fixed effects and Hospital× Service fixed effects are controlled. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

5.2 Impact on Patients

As noted in the previous section, hospitals' service repositioning leads to cost reductions for providers. In this section, we analyze the implications of service repositioning for patients. Service relocation can influence patients in several ways. First, service relocation can increase patients' travel distance. Second, service quality might change due to service repositioning. For

Figure 13: Event Study of Consolidated Service in 0-10 miles Mergers



instance, concentrating patient flows in single, specialized locations might lead to better patient outcomes because physicians will gain more experience in treating certain conditions. However, mergers might also lower health care quality due to a reduction in market competitiveness. Finally, the providers' cost reductions can be passed on to consumers in the form of lower claim prices. Due to data limitations, we do not observe the transaction prices of services. Thus, we analyze the impact on patients by investigating changes in service quality and patients' travel distance.

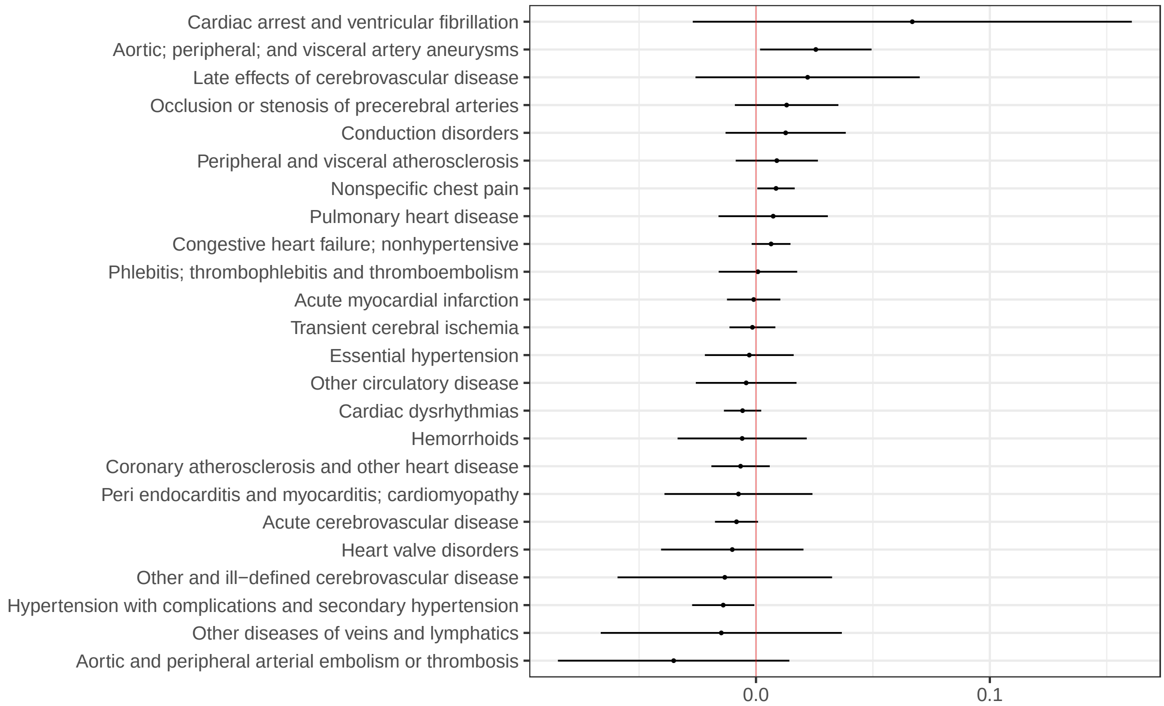
5.2.1 Service Quality

To evaluate the changes in service quality for the consolidated services, we examine the unplanned readmission rate of discharges. We concentrate on patients whose primary diagnosis relating to the consolidated services (circulatory/cardiac, birth delivery, and women's genital). For each patient discharge, the 30-day all-cause unplanned readmission record is identified following Horwitz et al. (2011). We also control for the Charlson comorbidity conditions to adjust the risk of patients (D'Hoore, Sicotte and Tilquin, 1993). Specifically, we analyze the change in readmission rates at the discharge level using the following equation

$$q_{jit} = \alpha_i + \gamma_t + \sum_g \lambda_g \cdot \mathbb{1}[t \geq \tau_i] \times \mathbb{1}[i \in \mathcal{G}_g] + \beta X_{jt} + \epsilon_{jit}, \tag{14}$$

where for patient j's discharge occurred in hospital i at time t, q_{jit} indicates whether any unplanned readmission happens to the patient within 30 days, α_i are hospital fixed effects, and γ_t are year fixed effects. $\mathbb{1}[t \geq \tau_i]$ is the indicator function showing whether hospital i is in

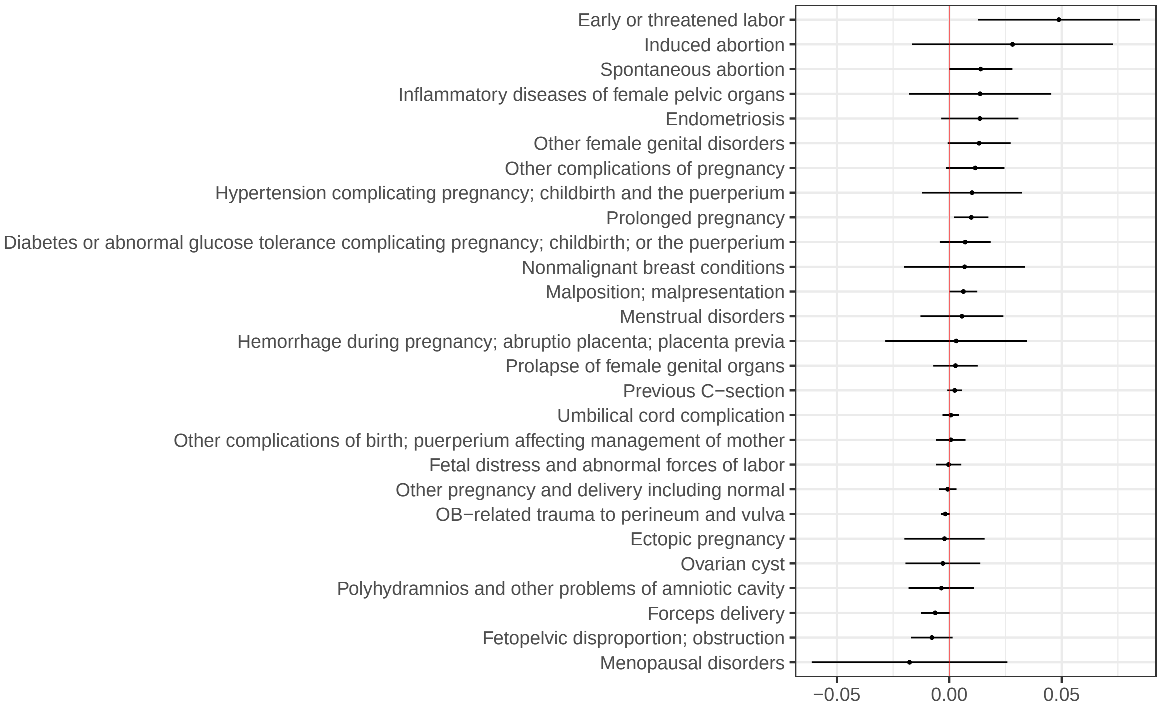
Figure 14: Post-Merger Change of Discharge Readmission in 0-10 mile Merging Hospitals, Discharges for Circulatory Diseases



post-merger status. When patient j is admitted by hospital i in merger distance group $\mathcal{G}_i$, λ_g represents the post-merger change in the readmissions for discharged patients that occurred in hospital i. Similar to before, $\mathcal{G}_g \in \{\mathcal{G}_1, \mathcal{G}_2\}$. $\mathcal{G}_1$ represents hospitals with merging counterparts that are within 10 miles, and $\mathcal{G}_2$ represents those whose merging counterparts are 10 to 100 miles away. X_{jt} stands for the Charlson comorbidity conditions for risk adjustment. We only include patient discharges from merging hospitals that are within 100 miles of each other, as before. Discharges with different primary diagnoses are separately analyzed.

The results are presented in Figures 14 and 15. Each row in these charts contains a primary care diagnosis. The value along the horizontal axis shows the post-merger change in the likelihood of unexpected readmission when a patient is discharged from a merging hospital within 10 miles. Figure 14 exhibits the results with discharges for circulatory diseases and Figure 15 shows the results for birth delivery and women's genital procedures. Overall, the readmission rate remains stable after mergers for these repositioned services. We find no evidence that service repositioning significantly changes the unplanned readmission rate.

Figure 15: Post-Merger Change of Discharge Readmission in 0-10 mile Merging Hospitals, Patients for Birth Delivery and Female Genital



5.2.2 Patient Travel Distance

Service relocation after a hospital merger can change the distance that patients have to travel to receive care. We calculate travel distance based on patients' home address five-digit zip code. The travel distance is calculated as the centroid of the zip code to the geolocation of the hospital, and travel time is the driving time to cover the distance under normal traffic conditions.[15] We also concentrate on patients who receive consolidated services in merging hospitals that are within 10 miles of each other. We implement the analysis using the following equation:

$$r_{jit} = \alpha_i + \gamma_t + \sum_g \lambda_g \cdot \mathbb{1}[t \geq \tau_i] \times \mathbb{1}[i \in \mathcal{G}_g] + \epsilon_{jit}. \tag{15}$$

where r_{jit} is the travel distance/time of patient j's discharge at hospital i at time t, α_i are hospital fixed effects, and γ_t are year fixed effects. $\mathbb{1}[t \geq \tau_i]$ is the indicator function showing whether hospital i is in post-merger status, and λ_g shows the post-merger average change in travel distance/time, with $\mathcal{G}_g \in \{\mathcal{G}_1, \mathcal{G}_2\}$. $\mathcal{G}_1$ represents hospitals with merging counterparts

[15]See Weber and Péclat (2017) for details

within 10 miles, and $\mathcal{G}_2$ represents those whose merging counterparts are 10 to 100 miles away.

The results are shown in Table 13. Column (1) presents travel time as the outcome variable, and column (2) uses travel distance as the dependent variable. The analysis indicates that both travel distance and travel time have a minor and insignificant increase. According to the estimation of Ho and Pakes (2014), the willingness to pay for one-mile travel distance is between \$100 and \$1500. In our context, this means that service relocation can lead to a decrease in consumer surplus by around \$50 to \$750 per discharge for consolidated services.

Table 13: Post Merger Effect of Travel Distance of Merged Hospitals within 100 mile

	(1) Travel Time (min)	(2) Travel Distance (mile)
Post merger of 0-10 miles	0.433	0.517
	(0.755)	(0.795)
Post merger of 10-100 miles	-0.048	-0.015
	(0.862)	(0.926)
N	4,530,729	4,530,729
R^2	0.004	0.003

6 Discussion and Conclusion

Employing a difference-in-differences study design, the research presented in this paper yields evidence that hospitals remove duplicate services after mergers. Merging hospitals that are geographically close (within 10 miles) eliminate about five duplicate services. This repositioning appears to generate significant cost savings of about 20% for the consolidated services. Our analysis provides systematic evidence supporting hospitals' claim that mergers can enable efficient reorganizations of services.

We also provide some partial evidence on how the repositioning of services might affect consumer welfare. First, service reorganization may lead to changes in service quality, but our analysis of some measures of hospital quality reveals no significant change. Second, the reallocation of patient flows can change patients' travel costs. Our results show that service repositioning after a hospital merger indeed leads to an increase in travel distance of about a half mile, which can be translated to patients' willingness to pay \$50 to \$750 per discharge for consolidated services.

Ultimately, antitrust enforcement is based on consumer welfare standards and concerns whether consumers can enjoy the benefits of the created surplus. Our paper opens up future research opportunities to study the pass-through of cost reductions to consumers. If the cost savings generated by service repositioning are not effectively transformed into price reduction, policy interventions may help to achieve this goal. One potential option is to impose a price-cap condition on the merger terms. For instance, in the merger of Beth Israel Deaconess Medical Center and Lahey Health System in Boston, the attorney general imposed a seven-year price-cap condition. Another potential solution to extract the surplus of service repositioning without creating market power is to form operating agreements across close facilities but prohibit them from joint price bargaining. For example, accountable care organizations of geographically close hospitals may improve the service repositioning across facilities by aligning their financial incentives. Meanwhile, accountable care organizations are not likely to experience price increases because hospitals are mainly paid under capitation from the Centers for Medicare and Medicaid Services.

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Appendix. (For Online Publication)

1.1 Illustrative Example of Service Repositioning

This section shows an illustrative example where hospitals hsave incentives to remove their duplicate services and how the distance between merging hospitals matters. We use a spatial differentiation model similar to Salop (1971)'s circular city. We assume a case with four hospitals $\{A, B, C, D\}$ evenly distributed on a circle, as in Figure 16. Each hospital offers two medical services (s^1, s^2). For simiplicity, we assume these hospitals are identical to consumers except their locations. For service s^i, hospitals have $mc^i = c^i$ for treating each unit of patients and fixed cost of entry f^i. For the consumers, they are distributed uniformly on a circle with circumference 1 and they can only travel on the circle. There are equally amounts of consumers separately seeking service s^1 and s^2 and we assume both type is of mass 1. For consumers seeking service s^i, consumers have unit demands and enjoy utility $V^i - xt - P^i$ if they decide to go to a hospital with x distance away and charge a price P^i. Additionally, we assume there are no other health providers could enter this market.

Before merger, four hospitals are competitors and do not share common ownership. By symmetricity, we have

$$P_A^1 = P_B^1 = P_C^1 = P_D^1 = \frac{t}{4} + c^1$$
$$Q_A^1 = Q_B^1 = Q_C^1 = Q_D^1 = \frac{1}{4}$$

Similarly, for s^2, we can solve that

$$P_A^2 = P_B^2 = P_C^2 = P_D^2 = \frac{t}{4} + c^2$$
$$Q_A^2 = Q_B^2 = Q_C^2 = Q_D^2 = \frac{1}{4}$$

Now we assume two adjacent hospitals, hospital A & B merged together. The newly merging hospital have two choices: 1) It can continue offer two services in both branches; 2) It could let two branches specialize in only one service. In the former case, the profit of the hospital is equal to:

$$\pi^{noRel} = [(\frac{t}{4} + c^1 - c^1)\frac{1}{4} + (\frac{t}{4} + c^2 - c^2)\frac{1}{4} - f^1 - f^2] * 2 = \frac{t}{4} - 2(f^1 + f^2)$$

If it chooses to specialize. Withourt loss of generosity, we suppose hospital A only offers s^1

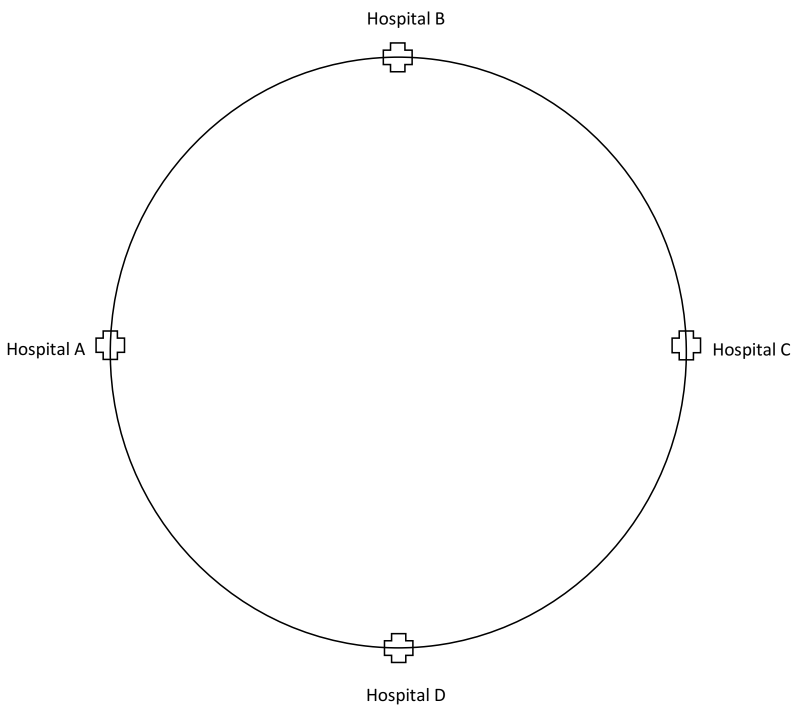


Figure 16: Ilustration of Hospital Distribution

while B only offers s^2. Solving this equilibrium, we have

$$P_A^1 = P_C^1 = \frac{7t}{20} + c^1, \quad P_D^1 = \frac{3t}{10} + c^1$$
$$Q_A^1 = Q_C^1 = \frac{7}{20}, \quad Q_D^1 = \frac{3}{10}$$

and for s^2, we can solve that

$$P_B^2 = P_D^2 = \frac{7t}{20} + c^2, \quad P_C^2 = \frac{3t}{10} + c^2$$
$$Q_B^2 = Q_D^2 = \frac{7}{20}, \quad Q_C^2 = \frac{3}{10}$$

As a result, the profit after relocating services is:

$$\pi^{Rel} = (\frac{7t}{20} + c^1 - c^1)\frac{7}{20} - f^1 + (\frac{7t}{20} + c^2 - c^2)\frac{7}{20} - f^2 = \frac{49t}{200} - (f^1 + f^2)$$

Therefore, when $f^1 + f^2 > \frac{t}{4} - \frac{49t}{200} = \frac{t}{200}$, the merged firm benefits from relocating services between two branches.

However, when it comes to the case that distant hospitals merged, for instance, hospital A & C merged together, they may not cut any service at all because they are competing with B and D. As A & C's close competitora offer both services, the decision of service removal depends on the tradeoff between the cost savings from removing services and the loss of profit due to consumers shifting away. The further the distance of merging hospitals, the larger the loss they have, because the consumers are more likely to choose competiting substitues.

1.2 Internal Validity Check

The main threat to our identification strategy is the selection of merger time. In other words, if there exists a correlation between the merger time and the time-path of the service change of hospitals, our results may bias. In this part, we present evidence to address the internal validity concern.

First, we check the summary statistics of hospitals across different merger time. We categorize the merger time into 3 groups, before (and includes) year 2005, year 2006-2010, and after (and includes) year 2011. Table 14 and Table 15 show the summary statistics of hospitals in the starting year by their merger time group. Table 14 shows the summary statistics of all merging hospitals with counterparts no further than 100 miles, and Table 15 shows the hospitals within merging counterparts within 10 miles. For both samples, we do not observe significant differences across the hospital characteristics.

Second, we conduct the validity test as De Janvry et al. (2015) to examine the correlation between merger time and the pre-merger service changes. We use a regression of pre-merger changes of the nunmber of services on the indicators for the merger years

$$\Delta n_{it} = \gamma_t + \sum_{k \geq t} \delta_k \cdot \mathbb{1}[\text{Merger Year}_i = k] + \epsilon_{it}, \quad \forall\ t \leq \text{Merger Year}_i \tag{16}$$

The dependent variable Δn_{it} is the number of services of hospital i, $n_{it} - n_{it-1}$ and γ_t stands for the year fixed effects. The parameter of interest is δ_k, which shows the relationship between the merger time (year k) and the change of the number of services with year fixed effects controlled. The joint significance of the merger time effects would imply that pre-merger service change is related to the merger time. Table 16 shows the results of this analysis. Column (1) uses the indicators of merger time group as the key indipendent variables and column (2) adopts the indicators of merger years. In both settings, the year of mergers do not significantly explain the pre-merger change of services.

Table 14: Summary Statistics of 100-mile Merging Hospitals by Merging Time

	2002-2005	2006-2010	2010-2014
Number of procedure classes provided	163.3	163.2	154.1
	(26.54)	(23.25)	(33.06)
Number of diagnosis classes provided	131.3	131.4	130.4
	(5.341)	(5.062)	(5.349)
Hospital HHI of procedures	837.3	1115.4	1266.6
	(425.5)	(654.9)	(923.0)
Hospital HHI of diagnoses	350.1	339.0	371.5
	(71.15)	(55.85)	(106.4)
Casemix index	1.077	1.062	1.049
	(0.187)	(0.171)	(0.297)
Number of staffed beds	204.8	204.5	183.1
	(159.3)	(117.1)	(116.7)
Total discharges	10796.1	9509.2	8995.0
	(7230.7)	(5147.4)	(6855.1)
Total discharge days (in thousand)	50.44	50.55	47.04
	(36.51)	(28.29)	(35.07)
Total patient care cost (in million)	127.1	101.3	111.1
	(106.0)	(68.96)	(88.79)

Table 15: Summary Statistics of 10-mile Merging Hospitals by Merging Time

	2002-2005	2006-2010	2010-2014
Number of procedure classes provided	156.1	160.0	158.8
	(26.45)	(22.51)	(30.07)
Number of diagnosis classes provided	129.1	130.5	129.5
	(6.122)	(5.493)	(6.933)
Hospital HHI of procedures	1117.5	1178.9	1136.8
	(479.6)	(591.9)	(700.5)
Hospital HHI of diagnoses	346.0	335.9	335.5
	(56.24)	(57.97)	(101.7)
Casemix index	1.069	1.050	1.124
	(0.259)	(0.177)	(0.335)
Number of staffed beds	167.7	173.4	208.9
	(76.66)	(85.54)	(140.2)
Total discharges	9189.7	8109.2	9868.2
	(5444.9)	(4085.5)	(8405.7)
Total discharge days (in thousand)	46.90	41.93	53.06
	(26.45)	(20.51)	(41.22)
Total patient care cost (in million)	90.67	83.66	125.5
	(69.86)	(52.88)	(100.1)

Table 16: Relationship between Merger Time & Pre-merger Service Change

	(1)	(2)
	Δ Number of Services	Δ Number of Services
Before 2005	-	
2006-2009	-0.199	
	(0.989)	
After 2010	0.307	
	(1.119)	
Merger year=2003		-
		-
Merger year=2004		-0.590
		(3.274)
Merger year=2005		-2.073
		(2.550)
Merger year=2006		-2.510
		(3.115)
Merger year=2007		-1.525
		(3.086)
Merger year=2008		-0.669
		(3.094)
Merger year=2009		-0.251
		(2.955)
Merger year=2010		-1.230
		(3.049)
Merger year=2011		0.049
		(2.811)
Merger year=2012		-2.809
		(3.116)
Merger year=2013		-0.165
		(2.986)
Merger year=2014		0.163
		(3.174)
N	514	514
R^2	0.02	0.04

1.3 Robustness with Different Distance Groups

Table 17: Post Merger Effect of Services across Merged Hospitals within 100 mile

	(1) Number of Services	(2) Number of Duplicate Srv	(3) Log HHI of Services	(4) Log HHI Non-removed Srv
Post merger of 0-10 miles	-4.733**	-6.774***	0.103**	0.088*
	(2.024)	(2.012)	(0.049)	(0.050)
Post merger of 10-40 miles	0.453	-5.480**	-0.034	-0.044
	(3.278)	(2.407)	(0.050)	(0.050)
Post merger of 40-70 miles	7.045**	3.393	0.016	0.033
	(3.399)	(6.558)	(0.055)	(0.055)
Post merger of 70-100 miles	6.072	5.887	0.067	0.078
	(5.741)	(4.803)	(0.111)	(0.111)
N	1208	1208	1208	1208
R^2	0.95	0.98	0.89	0.90

[1] Dependent variable in Column (1) is the total number of services of individual hospitals. Dependent variable in Column (2) is the number of duplicate services shared by hospitals and their closest merged counterparts Dependent variable in Column (3) is the log HHI of service volumes, and in (4) is the log HHI of services kept after mergers .

[2] Model clusters at individual hospital level. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

1.4 Supplement Results with the AHA data

The change we observe above could also be motivated by the financially poor-performed targets' intention to shrink their service spectrum, which is irrelevant with the service consolidation. There is a possibility that targets are financially constrained, and they would remove services even without occurrence of mergers. Under this case, the service removal would occur for the targets, while the acquirers which are of decent financial status might absorb the target hospitals. This mechanism would result in all the services elimination only on the target side, while the service consolidation leads to a simultaneous service exchange on both the targets and acquirers due to the service consolidation. To test whether the services repositioning only occurs on targets or both sides, we turn to the national sample from the AHA Annual Survey to form a large sample to study the effect with the targets and the acquirers separately. We use the same strategy in Section 4.1 to evaluate the change of services at the individual hospitals and hospital pairs. Table 18 presents the summary statistics of the mergers and acquirers at the beginning year of the AHA sample, year 2001. On average, the acquirer hospitals are larger than the targets, offering more services and treats more patients. Meanwhile, for the targets/acquirers having merger counterpart within 10 miles, they are more likely to be in metro areas, and are of larger size compared with the hospitals with further merging partners. The services from the

AHA data is listed in Table ?? in Appendix.

Table 18: Summary Statistics of AHA Data in Year 2001

	Targets in 10 miles	All Targets	Acquirers in 10 miles	All Acquirers
Number of services	28.47	23.04	32.60	25.51
	(10.01)	(11.32)	(12.05)	(12.26)
Total staffed beds	252.3	158.9	347.8	207.1
	(138.2)	(136.0)	(267.9)	(203.5)
Total admissions	10755.3	6556.4	15883.1	9241.1
	(6819.8)	(6207.4)	(12955.9)	(9912.0)
Local sys members	3.781	2.625	3.481	3.470
	(4.308)	(3.570)	(3.689)	(3.702)
Metro	0.562	0.427	0.596	0.486
	(0.499)	(0.495)	(0.492)	(0.500)

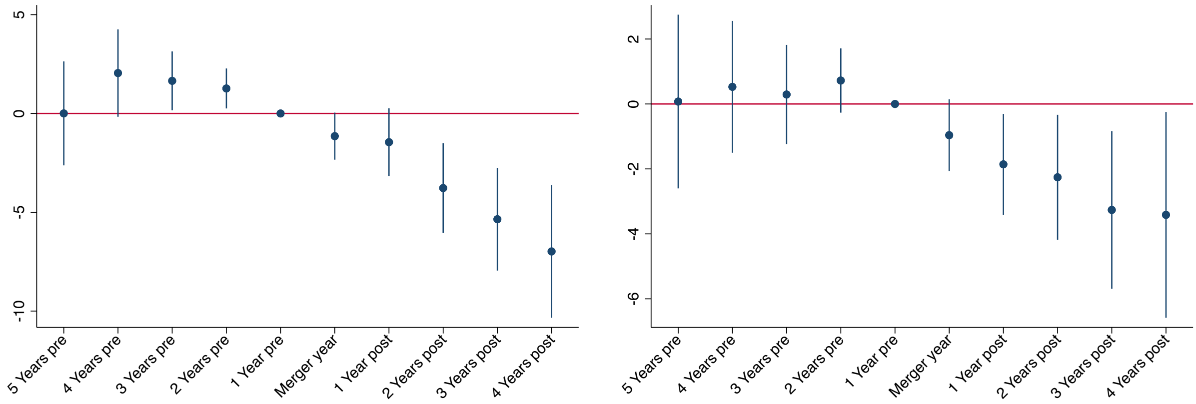
Table 19: Individual Hospital Number of Services for Mergers within 10 miles

	(1)	(2)
	Targets within 10 miles	Acquirers within 10 miles
Post merger	-2.544***	-1.816**
	(0.880)	(0.787)
N	1182	1657
R^2	0.88	0.92

Model clusters at individual hospital level. Total number of beds and for-profit status of hospitals are included in regressions. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Table 19 implements the two-way fixed effect models only with the target hospitals and acquirer hospitals within 10 miles separately. From Table 19, we can observe that the service elimination happens simultaneously at the targets and acquirers, and the targets drop more services compared to the acquirers. We decompose the effect by time in the event study in Figure 17, where the left panel is the event study with the targets sample in Table 19 column (1) and the right panel is the acquirers in Table 19 column (2). For the target hospitals, we observe that the service removal happens one year before the merger. The early service reposition of the target hospitals can be driven by the possible poor financial performance of targets so that they already shrink the spectrum of services covered. However, the parallel trend assumption holds for the acquirers. Meanwhile, the acquirer hospitals, which may not face financial stress as targets do, still eliminate some services, indicating the service removal we observe are not entirely driven by the worry of financial performance. The pair analysis results is attached in the Appendix. Overall, the service repositioning identified in the California sample also holds in the national sample from the AHA data.

Figure 17: Event Study of Number of Services for Hospitals within 10-mile Mergers



(a) Targets within 10 miles

(b) Acquirers within 10 miles

1.4.1 Robustness Check with the Propensity Score Matching Control

To deal with the pre-trend problem in the event study of the target hospitals in the AHA data, we run a robustness check using the unmerging control group built from the propensity score matching. Similar to Section 4.3.2, we match on the pre-merger outcome variable, the number of services of individual hospitals, and other hospital characteristics and market characteristics. The hospital characteristics include the number of beds, the number of annual admissions, and the number of hospitals affiliated with the hospital's system in the local market. Furthermore, the market characteristics we matched on are the number of hospitals in the local market, the metro status of the market, and the market HHI based on the hospitals' number of beds. Targets and acquirers are separately matched. Similar to before, we use a propensity score matching with a caliper to exclude the treatment hospitals without proper controls. Table 20 presents the summary statistics of the targets/acquirers within 10 miles and their matched controls of the beginning year in the sample. Compared to the targets' matched controls, the controls matched to acquirers are larger hospitals with more services, bed and admissions, and are more liekley to be in the metro areas.

Table 21 shows the results of the Diff-in-Diff analysis of within 10-mile targets/acquirers and their controls and the event study graph is presented in Figure 18. With the matched non-merging controls, the target hospitals remove approximately 3.5 services while the acquirers averagely decrease 2 services. Graph 18 shows the dynamic of the merger effect with time. For both targets and acquirers, the effect of service repositioning holds in both the short-run and

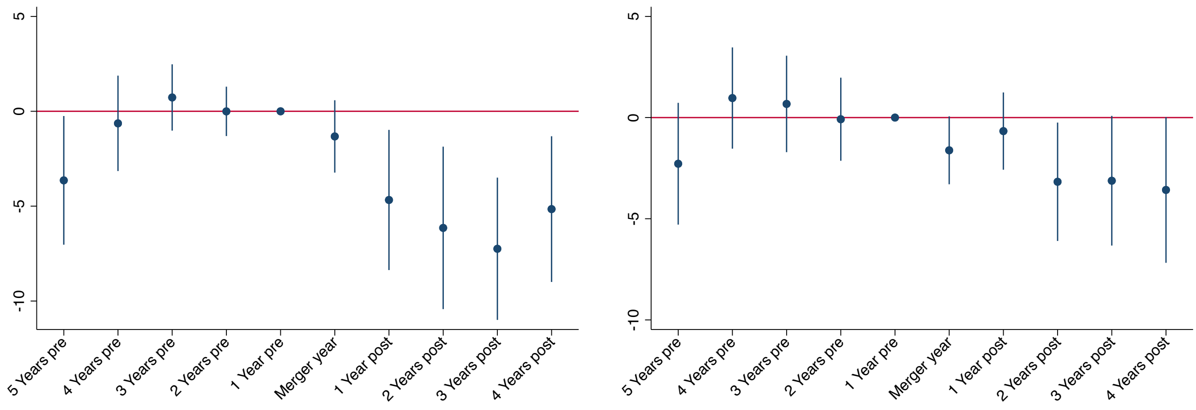
Table 20: Summary Statistics of Macthed Sample from AHA Data

	Targets		Acquirers	
	Within 10miles	Matched Control	Within 10 miles	Matched Controls
Number of services	28.59	25.26	32.32	28.02
	(10.08)	(14.82)	(11.72)	(14.95)
Total staffed beds	258.5	202.8	331.3	237.4
	(140.8)	(169.4)	(250.9)	(194.5)
Total admissions	11107.8	9515	15723.3	10023.0
	(6985.2)	(9024.4)	(13229.1)	(9224.5)
Local sys members	3.568	3.324	3.086	2.808
	(3.857)	(4.002)	(2.314)	(3.973)
Metro	0.630	0.559	0.664	0.587
	(0.486)	(0.500)	(0.474)	(0.495)

Table 21: Number of Services of Merged Hsopitals within 10 miles & Matched Controls

	(1)	(2)
	Targets within 10 miles	Acquirers within 10 miles
Post merger	-3.517***	-1.894*
	(1.340)	(1.059)
N	1789	2738
R^2	0.82	0.81

Figure 18: Event Study of Targerts/Acquirers within 10 miles & Matched Controls



(a) Targets

(b) Acquirers

long-run after mergers.

1.4.2 Hospital Pair Analysis

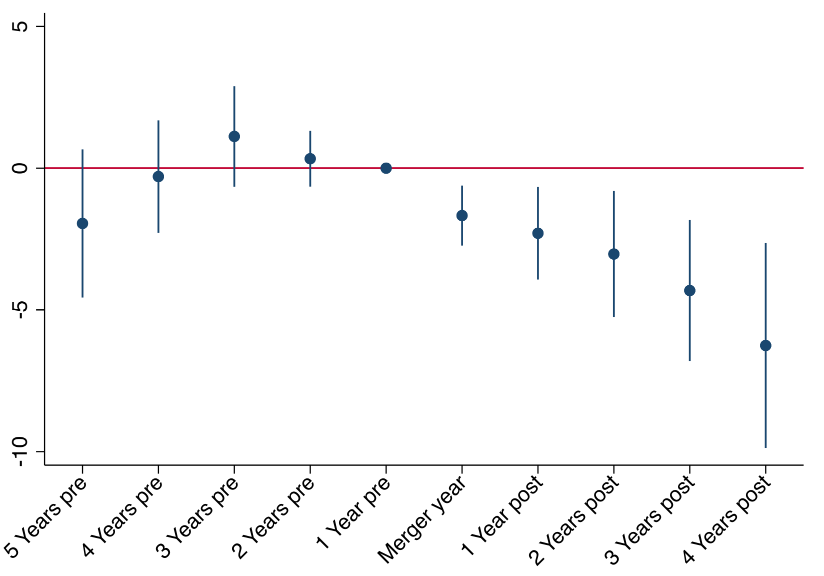
This section presents the analysis with the merging hospitals in the AHA data. Similar to before, we pair every two hospitals within the same market (Defined as Hospital Referral Region) and analysis the change of the total/duplicate services of the merging hospital pairs. The result is presented in Table 22. The sample still includes all the merging hospital pairs within 100 miles, and we estimate the heterogeneous effect of the same sample across different geographic distance group.

Table 22: Change of Total/Duplicative Services of Hospital Merged Pairs within 100 miles

	(1) Number of total services	(2) Number of duplicate services
Post merger of 0-10mile	-0.561	-2.496***
	(1.311)	(0.788)
Post merger of 10-40mile	-0.022	-0.095
	(0.581)	(0.439)
Post merger of 40-70mile	-1.690**	-0.047
	(0.709)	(0.496)
Post merger of 70-100mile	-0.999	-1.157**
	(1.044)	(0.558)
N	7467	7467
R^2	0.94	0.92

Column (1) in Table 22 presents the results with the hospital pairs' total number of services. The hospital pairs keep the similar number of services before and post mergers. However, in column (2), the merging hospitals pairs within 10 miles have a statistically significant drop of

Figure 19: Event Study of Merging Hospital Pairs within 10 miles in AHA Data



the duplicate services, indicating the occurrence of service repositioning for the merging hospital pairs in the close distance. We also conduct the event study of the merging hospital pairs within 10 miles in Figure 19. The analysis with the duplicate services does not reject the parallel pre-trend assumption, meanwhile, the decrease of duplicate services begins at the merger year and becomes larger as the time grows post merger.