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THE IMPACT OF HOSPITAL ACQUISITION OF PHYSICIAN PRACTICES ON REFERRAL PATTERNS

CAROLINE S. CARLIN[a,*], ROGER FELDMAN[b] and BRYAN DOWD[b]

[a]*Medica Research Institute, Minnetonka, MN, USA*
[b]*Division of Health Policy and Management, University of Minnesota Twin Cities, Minneapolis, MN, USA*

ABSTRACT

Multiple parties influence the choice of facility for hospital-based inpatient and outpatient services. The patient is the central figure, but their choice of facility is guided by their physician and influenced by hospital characteristics. This study estimated changes in referral patterns for inpatient admissions and outpatient diagnostic imaging associated with changes in ownership of three multispecialty clinic systems headquartered in Minneapolis-St. Paul, MN. These clinic systems were acquired by two hospital-owned integrated delivery systems (IDSs) in 2007, increasing the probability that hospital preferences influenced physician guidance on facility choice. We used a longitudinal dataset that allowed us to predict changes in referral patterns, controlling for health plan enrollee, coverage, and clinic system characteristics.

The results are an important empirical contribution to the literature examining the impact of hospital ownership on location of service. When this change in ownership forged new relationships, there was a significant reduction in the use of facilities historically selected for inpatient admissions and outpatient imaging and an increase in the use of the acquiring IDS's facilities. These changes were weaker in the IDS acquiring two clinic systems, suggesting that management of multiple acquisitions simultaneously may impact the ability of the IDS to build strong referral relationships. Copyright © 2015 John Wiley & Sons, Ltd.

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KEY WORDS: vertical integration; practice ownership; physician referrals

1. INTRODUCTION

1.1. Background

Multiple parties influence the choice of facility for hospital-based inpatient and outpatient services. The patient is the central figure in this process, but their choice of facility is guided by the recommendation of their physician, the physician's admitting privileges and incentives provided by hospital system (e.g., investment in quality improvement, scope of services offered, and choice of system location).[1] An increasing body of research suggests that the physician's guidance is a primary factor in a patient's choice of facility for inpatient and outpatient services (Birk and Henriksen, 2012; Bynum *et al*., 2007; Ikkersheim and Koolman, 2013; Kennedy and McConnell, 1993; Mahon *et al*., 1993; Trybou *et al*., 2011; Tu and Lauer, 2008). Because of this, a key motivation for hospital acquisition of physician practices is the ability to gain market share for inpatient admissions and outpatient services by capturing referrals from physicians employed by the owned practices (O'Malley *et al*., 2011; Felland *et al*., 2011).

However, there is a paucity of empirical research that documents the impact of vertical integration between hospitals and physician practices on referral patterns. This empirical study estimated changes in referral

*Correspondence to: Medica Research Institute, 401 Carlson Parkway, Minnetonka, MN 55305, USA. E-mail: caroline.carlin@medica.com
[1]Insurance characteristics such as provider network and copayment structure also may affect provider choice. In our data, enrollees have access to a broad network of participating providers with minimal copayment differences between in-network providers, so this impact is small.

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patterns for inpatient admissions and outpatient diagnostic imaging as a result of major changes in ownership of physician practices headquartered in the Minneapolis-St. Paul, MN, ('Twin Cities') metropolitan area. Three large, multispecialty clinic systems were acquired by two hospital-owned integrated delivery systems (IDSs) at the end of 2007. Using a longitudinal dataset that allowed us to control for health plan enrollee, coverage, and clinic system characteristics, we examined the impact of the clinic system acquisitions on referral patterns for inpatient admissions and outpatient diagnostic imaging.

1.2. Conceptual model

Our setting is distinct from that in much of the literature examining the connection between financial incentives and decisions about place of medical service. This literature is illustrated by Pauly (1979) and Ellis (1998), both modeling referrals from general practitioners to specialty care; David *et al*. (2013) modeling hospital discharge to postacute care; and Nakamura (2010) modeling referrals from nontertiary to tertiary hospitals. In all of these situations, the entity considering a referral (general practitioner, hospital discharging to a nonacute care facility, nontertiary hospital) may be able to continue providing the service themselves. In other words, a continuum exists from site-dedicated tasks that must be performed by the original provider, to shared tasks that can be performed in either setting, to site-dedicated tasks that must be performed by the provider receiving the referral, as described in David *et al*. (2013). These decisions about site of care may be influenced by changes in financial incentives because of side payments (Pauly, 1979), variation in patient profitability (Ellis, 1998), or the merging of financial interests resulting from vertical acquisition (David *et al*., 2013; Nakamura, 2010). In contrast, our study of vertical integration looks at plausibly site-dedicated tasks not performed in a clinic setting, so that there is no overlap of shared tasks. Therefore, our question is not whether a referral happens but which hospital system receives the referral. Specifically, these site-dedicated tasks are inpatient admissions, outpatient computed tomography (CT) scans, and outpatient magnetic resonance imaging (MRI) procedures.

Prior to acquisition, physician group J will refer patient i to hospital system A if the utility difference from that hospital system versus the next-best hospital system is positive: $\Delta U^i_{JA} > 0$. There will be a distribution of utility differences across all patients requiring these services, and those with a positive utility difference will be referred to hospital system A. Similarly, there will be a distribution of hospital profit from all potential referrals to hospital system A; for patient i, we denote hospital system A's profit as π^i_A. The range of the joint distribution of utility differences and profits for all patients is represented by the shaded area in Figure 1. If the physician operates independently and functions as an agent for the patient, the physician's utility difference incorporates both physician and patient preferences, but does not include the hospital's profitability. Thus, prior to acquisition, all cases to the right of the vertical line would be referred to hospital system A, regardless of hospital profit. Conversely, cases in the upper left quadrant would be profitable to hospital system A but are not referred to that system.

After the acquisition, the acquiring hospital system is able to provide financial and nonfinancial incentives to physicians in the acquired clinic system to align the physicians' post-acquisition utility with hospital profitability. These may include mechanisms such as revenue sharing or investment in an electronic health record system linking the hospital and clinic settings. (We know that in our setting, investment in electronic health record systems was a significant incentive for clinic systems to seek acquisition (Christianson *et al*., 2014), and one system shared that this investment was complete within 18 months of the acquisition date.) We denote the incentive to physicians in clinic system J for patient i's referral as $\Pi^i_{JA} = f\left(\pi^i_A\right)$. Thus, the postacquisition condition for physician group J to refer patient i to the acquiring hospital system A, relative to the next-best, nonacquiring hospital system is $\Delta U^i_{JA} + \Pi^i_{JA} > 0$. Assuming the sign of π^i_A and Π^i_{JA} are the same, we can represent the new referred population as the area to the right of the diagonal line in Figure 2 tracing $\Delta U^i_{JA} + \Pi^i_{JA} = 0$.

In Figure 2, the area between the diagonal line and vertical axis labeled X represents cases shifted to the acquiring hospital system, while the area labeled Y represents cases shifted away from the hospital system. Referrals after acquisition increase if the area of X is large relative to Y.

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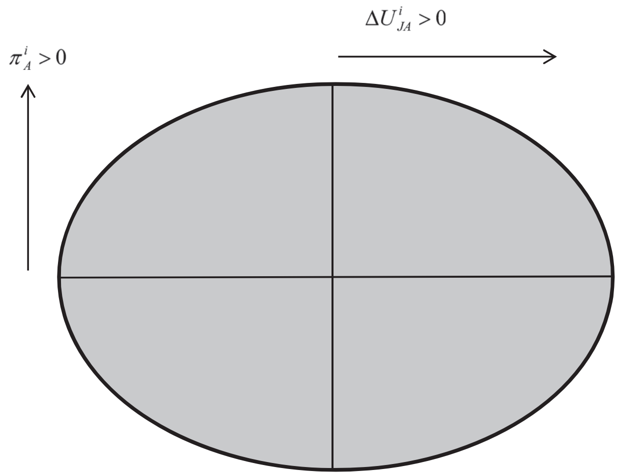

Figure 1. Physician group utility difference and hospital system profitability before acquisition

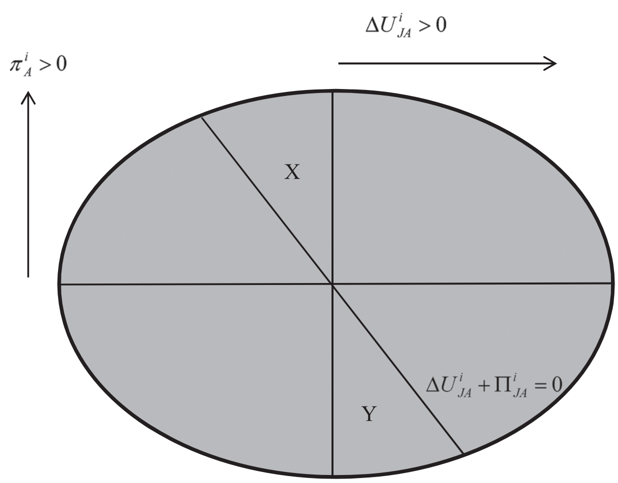

Figure 2. Physician group utility difference and hospital system profitability after acquisition

We would expect this shift, from basing the preacquisition referral decision on the physician's utility difference (incorporating physician and patient preferences) to the postacquisition utility difference that also includes hospital profits, to be greater when the physician's clinic system and the hospital system do not have a history of working together. This is equivalent to saying we would expect X to be large relative to Y when the physician's preacquisition utility difference is positive for only a small fraction of patients. If the hospital already gets a significant fraction of the physician's referrals, they most likely already have invested a portion of π^i_J in noneconomic incentives to increase physician-hospital alignment (Trybou *et al*., 2011). The potential to effect changes in referral patterns is greater when this alignment is historically weak.

It is important to understand that hospital ownership of a physician clinic does not mean that the physicians will exclusively refer to the acquiring hospital system. An examination of the claims history for individuals in our setting who received the majority of their primary care from vertically integrated systems reveals that approximately half of the allowed charges came from outside that system, much of this is driven by inpatient admissions. A further description of our setting is given in the succeeding text.

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2. METHODS

2.1. Study setting

Near the end of 2007, three large, multispecialty clinic systems were acquired by two hospital-owned IDSs headquartered in the Twin Cities. Using data from a regional health plan, we identified enrollees who were attributed by the health plan to one of 12 large clinic systems, a sample representing more than a quarter of the total population in the payer's commercial and managed Medicaid populations:

1. 'Treatment group' enrollees in the three newly acquired clinic systems (Acq1A, Acq1B, Acq2).
2. 'Control group' enrollees in the 'legacy' clinic systems that were already owned by the two acquiring IDSs (IDS1, IDS2). The acquiring hospital-owned IDSs provide both hospital and multispecialty clinic services. IDS1 acquired Acq1A and Acq1B, and IDS2 acquired Acq2.
3. 'Control group' enrollees in one of seven other clinic systems not affected by acquisitions. Three of the seven clinic systems are owned by vertically integrated, nonacquiring systems (IDS3, IDS4, IDS5) with a variety of ownership statuses: one is owned by an insurer, one by the physicians in the network, and one by the hospital system providing care in the IDS. Two additional clinic systems (MS1, MS2) are physician-only multispecialty clinic systems, and two are physician-only clinic systems with limited specialty services (PC1, PC2).

Enrollees were attributed to clinic systems based on a retrospective method that assigned them to the clinic system to which the plan paid the majority of their primary care dollars. For this purpose, primary care was defined by place of service (an office visit, or for Medicaid enrollees, an emergency department) and physician specialty code (general practice, internal medicine, family medicine, or OB-GYN). Attribution was based on allowed charges, which includes charges for covered services after provider discounts have been applied. The amounts paid by both the plan and the enrollee are included in the allowed charges.

The acquisitions did not necessarily coincide with historical referral relationships. Acq1A, which had a preacquisition (2006–2007) average of 59% of its enrollees' admissions in the IDS1 hospital system, was acquired by IDS1, causing little disruption. Of the remaining admissions, 21% of Acq1A enrollees were admitted to IDS5 hospitals prior to acquisition. On the other hand, Acq1B, which had a preacquisition average of 82% of its enrollees' admissions in IDS2, was acquired by IDS1, and Acq2, which had a preacquisition average of 83% of its enrollees' admissions in IDS1, was acquired by IDS2. We expected to see the strongest shift in referrals for enrollees attributed to the latter two acquired clinic systems because their historical alignment with the acquiring IDSs was weak.

We included observations from these 12 treatment and control clinic systems from 2 years prior to the acquisition (2006–2007) and 4 years after the acquisition (2008–2011). We estimated a difference-in-differences model, allowing us to control for time-invariant, unobserved characteristics of the clinic systems.

2.2. Data

We used commercial insurance and managed Medicaid data provided by a regional health plan in the upper Midwest for health plan enrollees whose care was attributed to one of the 12 clinic systems in our study during calendar years 2006–2011. This administrative data were matched with a prior-year health status[2] measure developed by the Johns Hopkins Ambulatory Care Group system (Weiner *et al*., 1992), using the system-generated categorical variable that indicates the following: no diagnosis on record; the enrollee was a healthy user of care; or the enrollee was in a low, moderate, high, or very high health-risk category. Finally, neighborhood effects were drawn from the 2011 5-year American Community Survey (U.S. Census Bureau, 2012) and

[2]We used prior-year health status to avoid issues of endogeneity, restricting our population to those who had at least 2 years of enrollment. This restriction has very little impact on the summary statistics of the population. The only meaningful difference is a modest increase in average age from 41.6 to 42.1

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matched at the census-tract level to the enrollee's address, prior to removing the address. The final limited dataset provided to the research team had all explicit identifiers removed, in accordance with methods approved by our Institutional Review Board.

2.3. Variables measuring referral patterns

We are interested in estimating changes in referral patterns due to the acquisition for patients attributed to the acquired clinic systems.[3] To estimate these changes, we needed to identify the facility that performed the service. We did this by using the identity of the hospital system billing for facility services associated with inpatient admissions, outpatient CT scans, and outpatient MRI procedures.

We included observations from outpatient imaging only if a facility fee was billed for this service. Because we are interested in observing the shift in referral patterns from one hospital system to another, we did not include CT scans and MRIs performed in a clinic setting—and thus charging no facility fee—in this analysis. None of the acquired clinic systems performed CT scans or MRIs within their clinic systems before or after the acquisitions.

A related question would be, does the acquisition of the clinic system cause clinic locations to be recharacterized as outpatient settings of the hospital and thus eligible to charge facility fees? Our model does not distinguish facility fees billed by a new outpatient site within the acquiring system from a shift of existing facility fees (from an outside system to the acquiring system). Because of this, emergence of new facility fees could confound the shift in referral patterns among providers charging facility fees. We did find some evidence of new, postacquisition facility fees being charged, but these were limited to new colonoscopy centers colocated with preexisting clinics, so we need not worry about confounding shifts in referral patterns with new locations charging facility fees for outpatient imaging.

For each inpatient admission or outpatient imaging procedure provided to enrollee i in year t, we defined the referral variable as

$$r_{it} = \begin{cases} 0 \text{ if admission/procedure facility fee was billed by an IDS1 location,} \\ 1 \text{ if admission/procedure facility fee was billed by an IDS2 location,} \\ 2 \text{ if admission/procedure facility fee was billed by other location.} \end{cases}$$

Note that a preacquisition tendency to refer from the acquired clinic system to the acquiring IDS was not identified as an acquisition effect. For example, Acq1A already had a strong relationship with the IDS1 hospitals, so we expect little increase in the postacquisition probability of an enrollee attributed to Acq1A using an IDS1 facility, that is, little change in Pr(IDS1 location) $\equiv$ Pr($r_{it} = 0$). On the other hand, the purchase of the Acq2 clinic system by IDS2 disrupted the previous admitting patterns, so we expect to see a larger increase in Pr(IDS2 location) $\equiv$ Pr($r_{it} = 1$) for enrollees attributed to Acq2 in the postacquisition years.

2.4. Econometric models

The unit of analysis is the individual inpatient admission or outpatient imaging procedure. We modeled the trinomial referral pattern (to IDS1 location, IDS2 location, or other location) using a multinomial logit framework, with errors clustered within the individual enrollee and fixed effects at the clinic system level. Because the treatment is determined at the clinic system level, an alternative approach would be clustering errors at the clinic system level. If we ignore the risk of bias due to within-enrollee correlation driven by unobservable enrollee characteristics and cluster at the clinic system level, we obtain nearly identical parameters to those shown here, with much smaller standard errors.

[3]We study the impact of acquisitions on quality of care (Carlin *et al*., 2014a) and prices (Carlin *et al*., 2014b) elsewhere.

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The value of the observed r_{it} is assumed to be determined by the relative values of three underlying latent variables r^*_{itk}, where $k \in \{0, 1, 2\}$. The observed $r_{it} = k^*$ if $r^*_{itk^*}$ is the maximum of the vector of latent variables r^*_{it}. The difference-in-differences model for each latent r^*_{itk} has the form :

$$r^*_{itk} = x'_{it}\beta^k_1 + \sum_{j=1}^{12} \beta^k_{2j}\text{ClinicSystem}_j + \sum_{t=2006}^{2011} \beta^k_{3t}\text{Year}_t + \sum_{j=1}^{3}\sum_{t=2007}^{2011} \beta^k_{4jt}\text{Treat}_{jt} + \varepsilon_{itk}$$

The indicators in *ClinicSystem* identify the clinic system to which the observation is attributed; the indicators in *Year* identify the year of observation; and the indicators in *Treat* identify whether the observation was from an enrollee in the treatment group, that is, an enrollee attributed to an acquired clinic system in a postacquisition year. The treatment clinic systems are identified by $j = 1$–3, and the postacquisition time frame by $t = 2008$–2011. Note that we include ‘treatment effects’ for the preacquisition year 2007 to confirm that the postacquisition effects seen are not merely a continuation of preacquisition trends. The treatment effects are the values of β^k_{4jt} for each outcome, estimating the impact of acquisition on the probability of referral to the kth hospital system (IDS1, IDS2, or other) for enrollees attributed to the jth acquired clinic system in year t. The reference value for *ClinicSystem* is IDS3, and for *Year* is 2006. Covariates controlling for observed characteristics of the enrollee and their environment are captured in the vector x'_{it}. We identified the model by defining the vector $\beta^2 = 0$, so the estimated parameters indicate the effect of the variable on referral to a hospital in IDS1 or IDS2 relative to the base option (other hospital systems).

3. RESULTS

3.1. Characteristics of the population

Summary statistics from the 796,962 person-years in the data are provided in Table I. The population had an average age of 42 years and 59% are female. Nearly half (49%) of the population was assigned a moderate health risk based on their prior-year diagnosis code history. Because the attributed population accessed primary care, it was a little older (1.3 years) and more female (7 percentage points) than the insurer’s full covered population.

On average, the enrollees’ neighborhoods were primarily White and non-Hispanic (84%), had residents who speak English only (88%), had residents with at least a high school degree (56% without a 4-year college degree, 36% with a 4-year degree), and had few households below the federal poverty limit (9%). There was a considerable amount of variation in these neighborhood effects across observations, as shown in Table I.

The most common type of insurance coverage was a broad preferred provider organization (PPO) network, but there was significant enrollment in a restricted-network plan that requires the designation of a medical home (18%), and in a managed Medicaid product (16%). Note that hospitals owned by the acquiring IDSs were available to all participants regardless of which plan they were in enrolled in; the acquisitions did not change the hospitals that were considered ‘in network’ for any enrollees. An examination of the distribution of observations by attributed clinic system shows considerable concentration of care delivery within the three largest IDSs in the region (IDS1, IDS2, and IDS3). Together, these three large systems represented 68% of the attributed enrollee-years in our data.

3.2. Inpatient admissions

Estimated parameters for the model of inpatient admission location are displayed in Table II, with marginal effects (and their 95% confidence intervals) displayed graphically in Figure 3. Marginal effects were computed as the average change in the predicted probability of an outcome if an observation was attributed to one of the acquired clinic systems in a postacquisition year, relative to the predicted preacquisition probability. The arrows in Figure 3 indicate the expected shift in admissions into the acquiring hospital system from their most significant preacquisition competitor. IDS1 already had a narrow majority (59%) of admissions for enrollees in Acq1A prior to acquisition, with IDS5 the nearest competing hospital system. Prior to acquisition, IDS2

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Table I. Summary of data

	Mean	Minimum	Maximum
Enrollee demographics			
Age (years)	42.1	18	85+
Female	59.1%		
Prior-year health status			
No diagnosis history	8.4%		
Healthy users	11.8%		
Low health risk	14.6%		
Moderate health risk	49.0%		
High health risk	12.8%		
Very high health risk	3.4%		
Neighborhood effects			
Less than high school/GED (%)	7.3	0.0	64.3
High school/GED but no bachelor's degree (%)	56.4	0.0	85.8
Bachelor's degree or higher (%)	36.3	0.4	95.1
White, non-Hispanic (%)	84.4	0.0	100.0
Speaking English only (%)	88.0	5.4	100.0
Households with income below the federal poverty limit (%)	8.6	0.0	92.4
Product			
Broad PPO network	65.7%		
Restricted network with medical home designation	18.0%		
Managed Medicaid plan	16.3%		
	Number of persons		
By attributed clinic system			
Treatment group			
Acq1A	44,928		
Acq2	31,200		
Acq1B	15,838		
Control group			
Clinics in acquiring IDS1	256,515		
Clinics in acquiring IDS2	113,057		
Clinics in other IDS3	171,749		
Clinics in other IDS4	58,080		
Clinics in other IDS5	30,922		
Physician-owned MS1	20,784		
Physician-owned MS2	16,191		
Physician-owned PC1	25,511		
Physician-owned PC2	11,623		
By calendar years			
2006	145,570		
2007	132,755		
2008	131,503		
2009	130,370		
2010	126,661		
2011	129,539		
Total number of persons (2006–2011)	796,398		

IDS, integrated delivery system; PPO, preferred provider organization; MS, multispecialty clinic system; PC, primary care clinic system; Acq, acquired clinic system.

had a large majority (84%) of admissions for Acq1B enrollees, and IDS1 had a large majority (83%) of admissions for Acq2 enrollees, creating potential for significant acquisition-related shifts in admissions for these enrollees.

By 2011, there was a statistically significant[4] shift in inpatient admissions away from the nearest competing hospital system for enrollees in all three acquired clinic systems, although the ability to capture those admissions in the acquiring hospital system was less pronounced. For enrollees attributed to Acq1A and Acq2, the 2011 marginal effects of acquisition are statistically significant increases in the probability the acquiring

[4]We define statistically significant as a p-value less than 0.05 and marginally significant as $0.05 < p < 0.10$.

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Table II. Regressions for Pr (inpatient admission in system *k*); 'Other' as reference value continued

	Pr (inpatient admission in system *k*)			
	IDS1 hospitals		IDS2 hospitals	
	Coefficient	Standard error	Coefficient	Standard error
Acquisition effect				
Acq1A 2007 (preacquisition)	−0.165	0.134	0.148	0.189
Acq1A 2008	−0.406**	0.157	0.225	0.215
Acq1A 2009	−0.004	0.146	0.240	0.208
Acq1A 2010	0.127	0.156	0.223	0.216
Acq1A 2011	0.521***	0.165	0.700***	0.241
Acq1B 2007 (preacquisition)	0.212	0.478	0.162	0.387
Acq1B 2008	−0.273	0.463	−0.227	0.432
Acq1B 2009	−1.009**	0.500	−0.447	0.365
Acq1B 2010	−0.167	0.474	−0.731*	0.393
Acq1B 2011	−0.287	0.447	−0.798**	0.396
Acq2 2007 (preacquisition)	−0.063	0.205	0.064	0.354
Acq2 2008	0.534**	0.251	1.459***	0.417
Acq2 2009	−0.229	0.208	0.983***	0.357
Acq2 2010	−0.382*	0.200	0.473	0.349
Acq2 2011	−1.450***	0.200	0.346	0.359
Age (years)				
18–22	Omitted		Omitted	
23–29	0.100*	0.051	−0.138**	0.068
30–44	0.119**	0.051	−0.087	0.069
45–59	0.055	0.054	−0.205***	0.076
60+	0.034	0.059	−0.472***	0.083
Female	0.285***	0.032	0.143***	0.047
Prior-year health status				
No diagnosis history	−0.044	0.067	0.026	0.105
Healthy users	Omitted		Omitted	
Low health risk	0.060	0.061	−0.158*	0.083
Moderate health risk	0.067	0.048	−0.045	0.063
High health risk	0.154***	0.051	0.118*	0.067
Very high health risk	0.092	0.062	0.396***	0.089
Neighborhood effects				
White non-Hispanic (%)	0.010***	0.002	0.007***	0.002
High school diploma, no 4-year degree (%)	0.028***	0.004	0.017***	0.006
4-year degree (%)	0.015***	0.004	0.016***	0.005
Income below federal poverty limit (%)	−0.019***	0.002	−0.007**	0.003
Speaking English only (%)	−0.026***	0.002	−0.013***	0.003
Product				
Broad PPO	Omitted		Omitted	
Narrow network	0.292***	0.037	−0.042	0.049
Medicaid	−0.003	0.034	−0.252***	0.046
Attributed clinic system				
Acq1A	2.653***	0.102	0.888***	0.142
Acq1B	2.422***	0.280	4.239***	0.234
Acq2	3.818***	0.142	1.214***	0.229
IDS1	3.282***	0.039	0.854***	0.056
IDS2	1.585***	0.063	3.906***	0.056
IDS3	Omitted		Omitted	
IDS4	1.472***	0.047	−0.540***	0.096
IDS5	−0.665***	0.087	−1.170***	0.139
MS1	−1.121***	0.099	−1.150***	0.108
MS2	−0.382***	0.113	−0.945***	0.182
PC1	0.105	0.094	−0.452***	0.168
PC2	1.982***	0.181	2.893***	0.160

(*Continues*)

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Table II. (Continued)

	Pr (inpatient admission in system k)			
	IDS1 hospitals		IDS2 hospitals	
	Coefficient	Standard error	Coefficient	Standard error
General trend				
2006	Omitted		Omitted	
2007	−0.021	0.039	−0.051	0.051
2008	−0.020	0.044	−0.044	0.061
2009	0.006	0.041	−0.097*	0.056
2010	−0.054	0.043	−0.109*	0.061
2011	−0.029	0.043	−0.197***	0.064
Constant	−2.627***	0.326	−2.493***	0.455
Pseudo R^2	0.363			
N	90,515			

IDS, integrated delivery system; PPO, preferred provider organization; MS, multispecialty clinic system; PC, primary care clinic system; Acq, acquired clinic system; Pr, probability of the event.
*0.05 < p-value < 0.10; **0.01 < p-value < 0.05; ***p-value < 0.01.

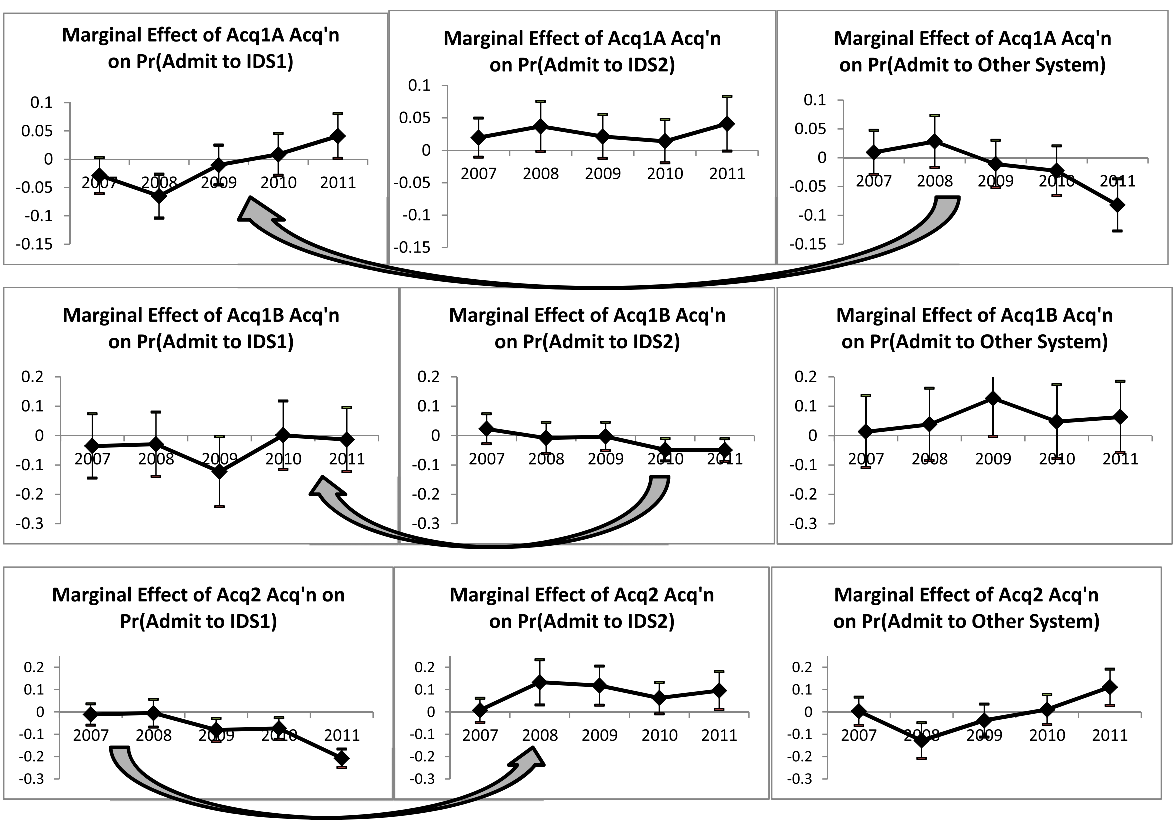

Figure 3. Marginal effects (95% CI) of acquisition on probability of admission by hospital network; arrows indicate expected shift; IDS, integrated delivery system; Pr, probability; Acq, acquired clinic system; Acq'n, acquisition

hospital will admit the enrollee (+4.1% for Acq1A, +9.6% for Acq2). IDS1 was less successful in capturing admissions from their Acq1B acquisition, perhaps indicating an initial focus on integrating the Acq1A clinic system, with which they had a stronger preacquisition relationship.

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The parameter estimates (Table II) show that, irrespective of acquisition activity, both IDS1 and IDS2 hospital systems were more likely to get the inpatient referral if the enrollee was younger or female. These large systems were attractive to the sickest members of the population. Relative to the broad PPO product, IDS1 and IDS2 were more likely to get the referral for enrollees in narrow-network products and IDS2 less likely for Medicaid enrollees. IDS2 appears to have experienced eroding inpatient market share over the course of this study.

3.3. Imaging referrals

Table III contains estimated parameters for the outpatient CT scan referral probabilities, and Table IV contains outpatient MRI referral parameter estimates. The marginal effects are displayed graphically in Figures 4 and 5 for CT scans and MRIs, respectively. Consistent with the inpatient admission patterns, we see greater success moving outpatient imaging referrals away from the principal preacquisition competitor than in capturing the referrals by the acquiring hospital system. These reductions in the probability of CT scan referral to the principal competitor are statistically significant by 2011 for enrollees in all three acquisitions (ranging from −4.7% to −9.1% in Figure 4). The acquiring hospital system's ability to capture these referrals is marginally significant only for Acq1A, where IDS1 saw a 5.4% increase in 2011 CT referral probability for Acq1A enrollees. Primarily because of smaller sample size, in Figure 5, we see the reduction in the probability of an outpatient MRI referral to the principal competitor is statistically significant by 2011 only for Acq2 enrollees (−19.2%), and marginally significant for Acq1A enrollees (−7.8%). IDS2 achieved a statistically significant 23.6% increase in the 2011 probability of getting a referral for an outpatient MRI among Acq2 enrollees.

In addition to the acquisition-related effects discussed, Tables III and IV provide insights into general trends in referral patterns. There was much less variation in referral patterns by age for outpatient imaging than for inpatient admissions; facilities in the two acquiring IDSs appear to have been more attractive than other facilities across a wide range of ages. Referral patterns to IDS2 for women were not significantly different from the other locations, but IDS1 was more likely to provide CT scans and less likely to provide MRIs to women. Consistent with inpatient referral patterns, these large systems were most attractive to the sickest patients for imaging services. Both imaging services were more likely in IDS1 for enrollees in narrow network and Medicaid products. IDS1 and IDS2 facilities experienced eroding market share for outpatient CT scans; in IDS1, this was balanced by improved market share for outpatient MRIs.

3.4. Robustness of results

Because our model structure is complex, it is possible that our choice of controls is not the appropriate counterfactual for the acquisitions. In particular, observations for enrollees in the 'always acquired' clinics (IDS1–IDS5) may be inappropriate comparators. Therefore, we re-estimated all models using only observations from the multispecialty clinic systems that remained physician-owned (MS1, MS2) as controls. The treatment effects with this alternative control group were consistent in direction and magnitude for the statistically significant results discussed, although the smaller sample size affected the precision of the estimates.

In addition, our ability to observe individuals across time is limited by the voluntary nature of enrollment in the health plan. Therefore, we also tested robustness to the unbalanced nature of our panel. We re-estimated all models using the subpopulation that had at least 12 months of attributed enrollment prior to the acquisition date and 12 months of attributed enrollment after the acquisition date. Again, the treatment effects discussed earlier were robust in this analysis. The results of all nonreported analyses are available from the corresponding author on request.

Finally, we ran two placebo tests to rule out the possibility that the shifts in referral seen are the results of factors unrelated to the acquisitions. The first test is the inclusion of preacquisition (2007) 'treatment effects' as noted earlier and seen in Tables II–IV. If the acquisition effects were merely a continuation of preacquisition trend, we should see an effect in 2007. These 2007 effects are generally small and not statistically significant. The only statistically significant placebo acquisition effect (Table III, Acq 2) has a sign

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Table III. Regressions for Pr (OP CT scan facility fee from system *k*); 'Other' as reference value

	Pr (OP CT scan facility fee from system *k*)			
	IDS1 facilities		IDS2 facilities	
	Coefficient	Standard error	Coefficient	Standard error
Acquisition effect				
Acq1A 2007 (preacquisition)	−0.229	0.184	0.099	0.280
Acq1A 2008	−0.155	0.206	0.140	0.351
Acq1A 2009	0.264	0.200	0.372	0.301
Acq1A 2010	0.131	0.223	0.354	0.311
Acq1A 2011	0.463**	0.213	0.444	0.311
Acq1B 2007 (preacquisition)	−0.154	0.598	−0.539	0.482
Acq1B 2008	−0.812	0.611	−1.094**	0.442
Acq1B 2009	0.110	0.559	−0.262	0.456
Acq1B 2010	−0.754	0.554	−0.928**	0.452
Acq1B 2011	−0.048	0.505	−0.597	0.409
Acq2 2007 (preacquisition)	−0.074	0.291	−1.252**	0.581
Acq2 2008	−0.465*	0.262	−0.330	0.525
Acq2 2009	−0.229	0.267	0.013	0.476
Acq2 2010	−0.669***	0.255	−0.423	0.524
Acq2 2011	−0.477*	0.256	0.401	0.462
Age (years)				
18–22	Omitted		Omitted	
23–29	0.266***	0.075	0.273**	0.105
30–44	0.372***	0.068	0.314***	0.095
45–59	0.338***	0.069	0.320***	0.095
60+	0.334***	0.078	0.243**	0.108
Female	0.073**	0.036	−0.013	0.050
Prior-year health status				
No diagnosis history	−0.051	0.083	0.005	0.115
Healthy users	Omitted		Omitted	
Low health risk	0.031	0.074	−0.059	0.100
Moderate health risk	0.085	0.060	0.047	0.083
High health risk	0.144**	0.065	0.155*	0.092
Very high health risk	0.118	0.075	0.446***	0.107
Neighborhood effects				
White non-Hispanic (%)	0.012***	0.002	0.008***	0.003
High school diploma, no 4-year degree (%)	0.016***	0.005	0.027***	0.008
4-year degree (%)	0.007	0.005	0.023***	0.007
Income below federal poverty limit (%)	−0.016***	0.003	−0.008	0.005
Speaking English only (%)	−0.024***	0.003	−0.009**	0.004
Product				
Broad PPO	Omitted		Omitted	
Narrow network	0.367***	0.048	0.110	0.070
Medicaid	0.125***	0.043	−0.068	0.060
Attributed clinic system				
Acq1A	1.828***	0.137	0.875***	0.215
Acq1B	1.824***	0.379	4.418***	0.310
Acq2	3.201***	0.194	1.435***	0.394
IDS1	2.496***	0.049	0.950***	0.072
IDS2	1.244***	0.078	4.092***	0.069
IDS3	Omitted		Omitted	
IDS4	1.002***	0.067	−0.036	0.122
IDS5	−1.026***	0.102	−0.986***	0.188
MS1	−0.283**	0.112	−0.172	0.175
MS2	−0.783***	0.250	−0.888***	0.286
PC1	−0.484***	0.125	−0.457*	0.235
PC2	0.584***	0.191	2.204***	0.166

(*Continues*)

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Table III. (Continued)

	Pr (OP CT scan facility fee from system *k*)			
	IDS1 facilities		IDS2 facilities	
	Coefficient	Standard error	Coefficient	Standard error
General trend				
2006	Omitted		Omitted	
2007	0.069	0.048	0.021	0.065
2008	−0.003	0.054	0.039	0.077
2009	−0.056	0.051	−0.069	0.068
2010	−0.107**	0.050	−0.169**	0.071
2011	−0.153***	0.050	−0.153**	0.072
Constant	−1.832***	0.434	−4.412***	0.688
Pseudo R^2	0.316			
N	90,285			

OP, outpatient; CT, computed tomography; IDS, integrated delivery system; Acq, acquired clinic system; PPO, preferred provider organization; MS, multispecialty clinic system; PC, primary care clinic system; Pr, probability of the event.
*$0.05 < p$-value < 0.10; **$0.01 < p$-value < 0.05; ***p-value < 0.01.

opposite of the subsequent postacquisition parameters. The second placebo test[5] examines the impact of the acquisition on emergency department visits, because we expect proximity of facility to be a greater driver than clinic ownership on choice of emergency department. We find the impact of acquisition to be generally weak, and where it is statistically significant the impact is inconsistent with the expected patterns because of acquisitions.

4. DISCUSSION

In documenting these acquisition-related changes in referral patterns, it is natural to wonder whether there was a particular kind of patient, admission, or procedure that was the focus of these changes. Did hospitals cream-skim by avoiding complex cases, given the fixed inpatient reimbursement within each diagnosis-related group? Were high-revenue procedures[6] a greater focus of changing referral patterns? To expand the results shown earlier, we estimated models that included interactions of an average postacquisition treatment indicator with an indicator of complex health status (high or very high risk patient) and with standardized fees by CPT4 code or DRG.[7] We found no evidence that the acquiring IDSs avoided complex patients, but some evidence that revenue differences were associated with changes in referral patterns. Higher-revenue inpatient admissions were more likely to be referred to the acquiring hospital system for enrollees attributed to Acq1A and Acq2. The association between revenue and referral patterns was weak and mixed for imaging; this lack of significance may be due to the smaller dollar range of revenue for CT scans and MRI procedures compared with the more diverse types of inpatient admissions. Marginal effects for all of these regressions, supplemented with a table showing the most prevalent diagnostic categories for inpatient admissions and outpatient imaging, are included in the Appendix of the Supporting Information.

These results are an important empirical contribution to the literature examining the impact of vertical integration of clinic systems with hospital systems on the location of health care delivery. When this change in

[5]Marginal effects displayed in Appendix of the Supporting Information.
[6]Unfortunately, we are unable to observe costs or profitability and therefore focus on the association between a standardized measure of revenue and referral patterns. If profits and revenue are proportional, the association we find suggests a tendency for IDSs to focus their efforts to change referral patterns on the more profitable procedures.
[7]The development of these standardized fees is described in Carlin et al., (2014b).

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Table IV. Regressions for Pr (OP MRI facility fee from system k); 'Other' as reference value

	Pr (OP MRI facility fee from system k)			
	IDS1 facilities		IDS2 facilities	
	Coefficient	Standard error	Coefficient	Standard error
Acquisition effect				
Acq1A 2007 (preacquisition)	−0.061	0.368	−0.219	0.546
Acq1A 2008	−0.070	0.434	0.377	0.642
Acq1A 2009	0.311	0.375	0.181	0.545
Acq1A 2010	0.302	0.386	−0.148	0.586
Acq1A 2011	0.585	0.371	0.678	0.512
Acq1B 2007 (preacquisition)	−0.662	0.833	−0.964	0.735
Acq1B 2008	−0.543	1.082	−0.074	0.971
Acq1B 2009	−0.904	0.943	−0.219	0.827
Acq1B 2010	−1.560*	0.880	−1.528*	0.782
Acq1B 2011	−0.450	0.899	−0.868	0.890
Acq2 2007 (preacquisition)	0.255	0.585	0.984	0.934
Acq2 2008	−1.002**	0.494	0.362	0.838
Acq2 2009	−0.495	0.548	1.780**	0.799
Acq2 2010	−1.277***	0.460	0.675	0.774
Acq2 2011	−0.930*	0.482	1.877**	0.767
Age (years)				
18–22	Omitted		Omitted	
23–29	0.392***	0.139	0.506**	0.241
30–44	0.505***	0.130	0.393*	0.229
45–59	0.301**	0.129	0.280	0.227
60+	0.312**	0.140	0.306	0.243
Female	−0.144***	0.051	0.076	0.071
Prior-year health status				
No diagnosis history	−0.029	0.121	0.055	0.159
Healthy users	Omitted		Omitted	
Low health risk	−0.172	0.106	0.040	0.147
Moderate health risk	−0.086	0.090	−0.041	0.117
High health risk	0.013	0.097	0.055	0.131
Very high health risk	0.269**	0.134	0.408**	0.167
Neighborhood effects				
White non-Hispanic (%)	0.012***	0.003	0.006	0.004
High school diploma, no 4-year degree (%)	0.017**	0.008	0.021*	0.011
4-year degree (%)	0.016**	0.007	0.019**	0.010
Income below federal poverty limit (%)	−0.015***	0.004	−0.007	0.006
Speaking English only (%)	−0.027***	0.005	−0.001	0.006
Product				
Broad PPO	Omitted		Omitted	
Narrow network	0.444***	0.065	−0.042	0.088
Medicaid	0.168**	0.067	−0.114	0.094
Attributed clinic system				
Acq1A	2.173***	0.270	1.608***	0.383
Acq1B	2.971***	0.689	4.514***	0.559
Acq2	3.449***	0.325	2.030***	0.689
IDS1	3.043***	0.064	1.260***	0.111
IDS2	2.027***	0.126	5.987***	0.117
IDS3	Omitted		Omitted	
IDS4	0.378***	0.140	0.304**	0.150
IDS5	−1.491***	0.176	−0.564**	0.222
MS1	−1.136***	0.196	0.097	0.219
MS2	−0.290	0.241	−0.497	0.323
PC1	−0.233	0.186	0.658**	0.273
PC2	1.674***	0.286	3.333***	0.263

(*Continues*)

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Table IV. (Continued)

	Pr (OP MRI facility fee from system *k*)			
	IDS1 facilities		IDS2 facilities	
	Coefficient	Standard error	Coefficient	Standard error
General trend				
2006	Omitted		Omitted	
2007	0.167**	0.071	0.078	0.101
2008	0.221***	0.074	0.125	0.116
2009	0.053	0.074	−0.095	0.105
2010	0.275***	0.073	0.071	0.109
2011	0.142*	0.073	−0.089	0.108
Constant	−2.155***	0.635	−5.384***	0.932
Pseudo R^2	0.467			
N	29,827			

OP, outpatient; MRI, magnetic resonance imaging; IDS, integrated delivery system; Acq, acquired clinic system; PPO, preferred provider organization; MS, multispecialty clinic system; PC, primary care clinic system; Pr, probability of the event.
*0.05 < *p*-value < 0.10; **0.01 < *p*-value < 0.05; ***p-value < 0.01.

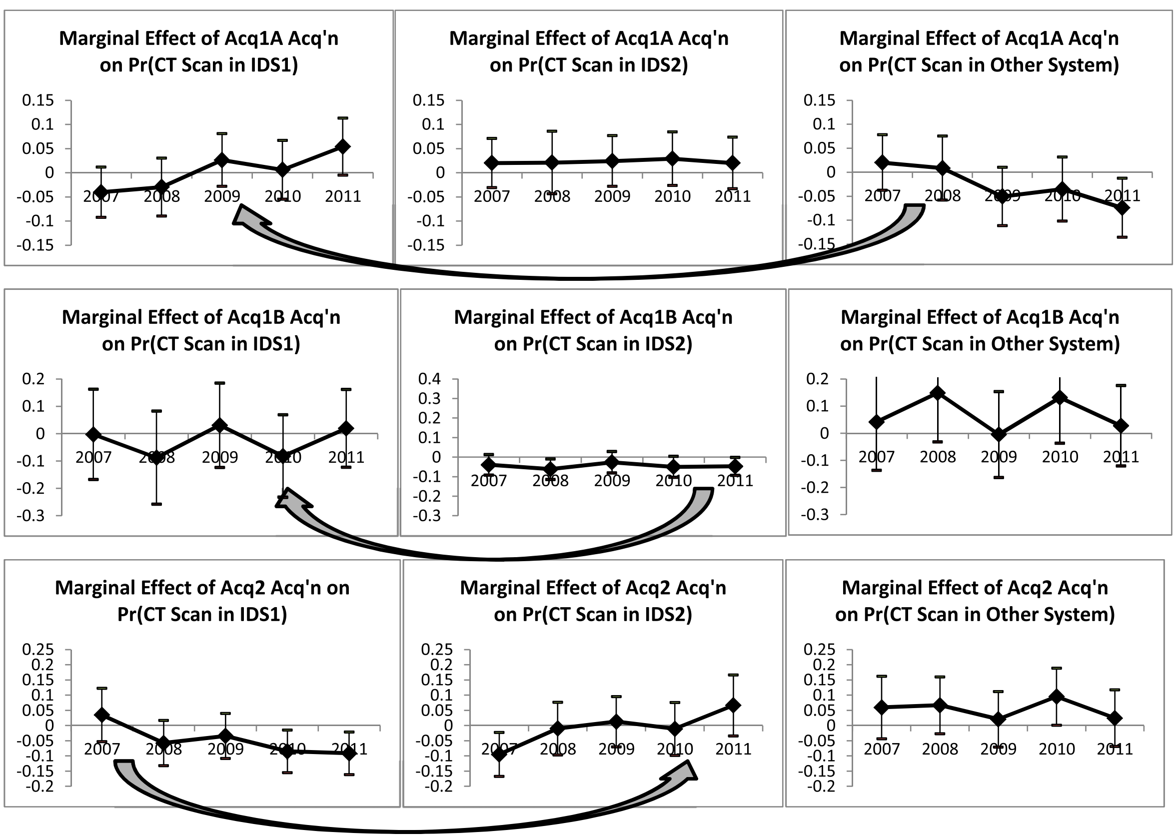

Figure 4. Marginal effects (95% CIs) of acquisition on probability of CT scan by hospital network; arrows indicate expected shift

ownership forges new relationships, there is a significant reduction in the use of facilities historically selected for inpatient admissions and outpatient imaging and an increase in the use of the acquiring IDS's facilities for enrollees receiving primary care from the acquired clinic systems. These changes are weaker for IDS1's

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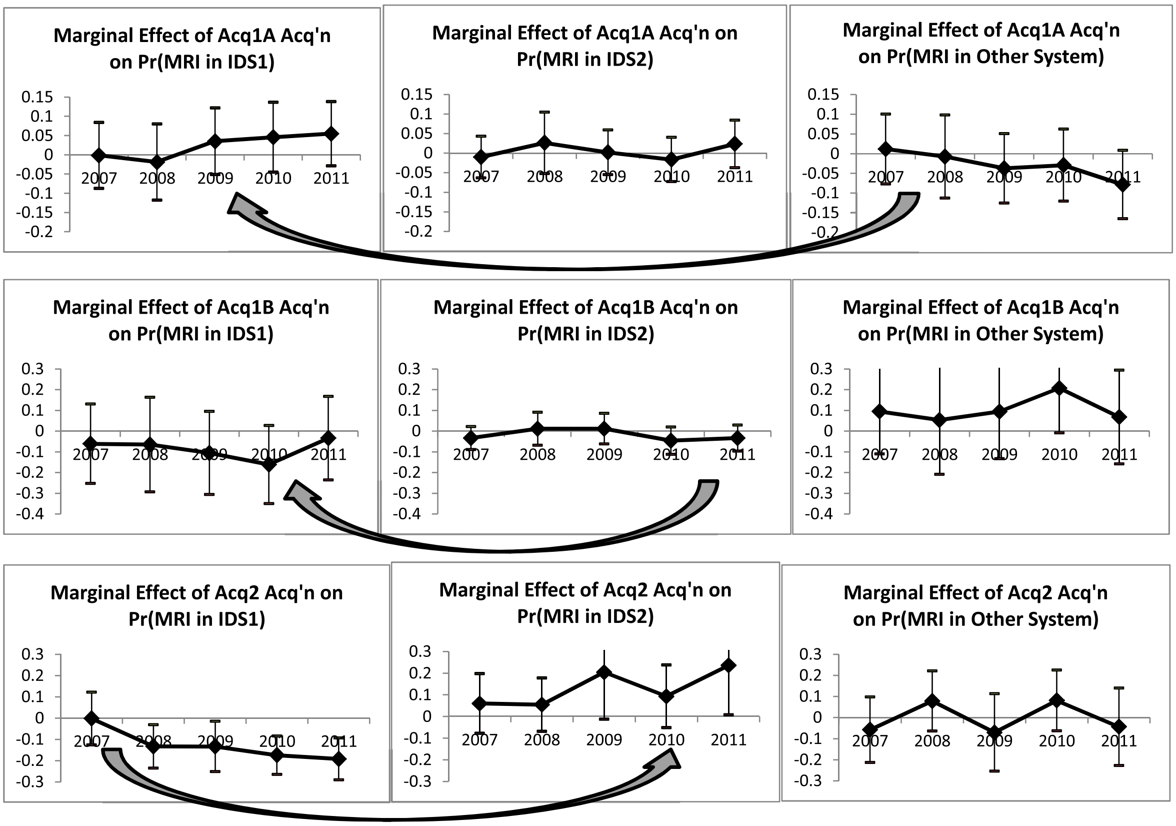

Figure 5. Marginal Effects (95% CIs) of acquisition on probability of MRI by hospital network; arrows indicate expected shift

acquisition of Acq1B, suggesting that management of two large acquisitions simultaneously may impact the ability of an IDS to effectively build new referral relationships.

CONFLICT OF INTEREST

No conflicts of interest reported.

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