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## Post-acute referral patterns for hospitals and implications for bundled payment initiatives



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### ABSTRACT

**Background:** Under new bundled payment models, hospitals are financially responsible for post-acute care delivered by providers such as skilled nursing facilities (SNFs) and home health agencies (HHAs). The hope is that hospitals will use post-acute care more prudently and better coordinate care with post-acute providers. However, little is known about existing patterns in hospitals' referrals to post-acute providers.

**Methods:** Post-acute provider referrals were identified using SNF and HHA claims within 14 days following hospital discharge. Hospital post-acute care network size and concentration were estimated across hospital types and regions. The 2008 Medicare Provider Analysis and Review claims for acute hospitals and SNFs, and the 100% HHA Standard Analytic Files were used.

**Results:** The mean post-acute care network size for U.S. hospitals included 57.9 providers with 37.5 SNFs and 23.4 HHAs. The majority of these providers (65.7% of SNFs, 60.9% of HHAs) accounted for 1 percent or less of a hospital's referrals and classified as "low-volume". Other post-acute providers we classified as routine. The mean network size for routine providers was greater for larger hospitals, teaching hospitals and in regions with higher per capita post-acute care spending.

**Conclusions:** The average hospital works with over 50 different post-acute providers. Moreover, the size of post-acute care networks varies considerably geographically and by hospital characteristics. These results provide context on the complex task hospitals will face in coordinating care with post-acute providers and cutting costs under new bundled payment models.

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### 1. Introduction

The Centers for Medicare and Medicaid Services (CMS) is transitioning away from fee-for-service reimbursement systems towards alternative payment models like bundled payments.<sup>1</sup> The agency is piloting multiple bundled payment models that provide incentives to improve integration and care coordination among providers.

One key provider relationship where care coordination is essential is the relationship between acute care hospitals and post-acute providers such as skilled nursing facilities (SNFs) and

home health agencies (HHAs). Research has demonstrated that post-acute provider spending drives much of the spending variation across hospitals and geographic regions and constitutes a major contributor to the recent growth in Medicare spending.<sup>2–5</sup> Under new bundled payment models, hospitals bear financial responsibility for the care provided by post-acute providers.<sup>6</sup> The hope is that hospitals will be more prudent in their use of post-acute care, improve care coordination with post-acute providers, and encourage its patients to receive care at low-cost and high-quality post-acute providers.

The potential cost savings of new bundled payment models are appealing and widely discussed, but potential implementation barriers have received little attention. Hospitals will need to evaluate which post-acute providers they refer patients to, coordinate care with those providers, and potentially develop

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contractual relationships with these providers to better manage utilization and care provision after hospital discharge. Although some hospitals are part of larger integrated delivery systems that include post-acute providers, prior work has noted that hospitals typically have weak clinical relationships with post-acute providers.<sup>7,8</sup>

Moreover, hospitals efforts to improve coordination may also conflict with policymakers' desires to preserve patient choice. As part of the conditions to participate in CMS's bundled payment pilots, hospitals are specifically prohibited from limiting patient choice regarding post-acute providers.<sup>9</sup> Therefore, even if hospitals are able to improve coordination with some post-acute care providers or identify low-cost high-quality providers, there is no guarantee that their patients will select these providers after discharge. Much like an Accountable Care Organization's inability to prevent "leakage" of its patients to providers outside its organization,<sup>10</sup> the inability to influence patient post-acute care choice may expose the hospital to sizeable financial risks that are beyond the hospital's control under new bundled payment models.<sup>11</sup>

The extent of potential coordination and provider "leakage" problems that hospitals will face will be largely influenced by each hospital's post-acute provider network. Previous studies have noted the size of post-acute referral networks may affect the success of these payment models.<sup>6</sup> However, currently, relatively little is known about current hospital post-acute referral network size and concentration and how they might vary with hospital characteristics and geographic regions. To help fill this gap in knowledge, we describe current post-acute hospital referral networks for SNFs and HHAs.

## 2. Methods

### 2.1. Data source

Our analysis of post-acute provider networks for U.S. hospitals used the 2008 Medicare Provider Analysis and Review claims for acute hospitals and SNFs, and the 100% home health Standard Analytic Files. Together, the files contain the complete set of non-managed care Medicare hospital, nursing home, and home health discharges. We relied upon the 100% Medicare Denominator file to obtain patient characteristics and the Medicare Provider of Services files to determine each hospital's location. Employing the American Hospital Association database, we determined each hospital's teaching status, size, ownership type and safety net status. We used a file published by the Institute of Medicine titled "Hospital Referral Region (HRR) Level Demographic, Cost, Utilization, and Quality Data" to determine risk-adjusted per capita Medicare inpatient and post-acute care spending and 30 day readmission rates for each HRR.<sup>12</sup> This file was created using Medicare claims data from CMS's Chronic Conditions Warehouse. All data came from 2008, the most recent year with fully available data at the outset of the study.

We identified all hospitalizations for Medicare beneficiaries aged 65 and older enrolled in both Parts A and B for the entire year. We excluded beneficiaries that were disabled or had end stage renal disease, were enrolled in a Medicare Advantage plan at any time in 2008, or lived outside the United States (e.g., Puerto Rico). We also excluded claims from Maryland providers because the state's hospital payment system is managed by the Health Services Cost Review Commission, an independent state agency, and is not necessarily subject to future federal bundled payment reform.<sup>13</sup>

### 2.2. Post-acute care referral networks

We examined hospitals' post-acute referral network size and concentration for referrals to SNFs and HHAs, as they represent the most common post-acute provider types. To construct hospital-specific post-acute care referral networks, we started with all 2008 discharges from acute care hospitals. Because actual hospital referrals to post-acute providers are not recorded in claims, we used patterns in the claims data to infer referrals. We defined a post-acute care referral as a claim for post-acute care services that occurred within 14 days following a patient's discharge from an acute hospital in 2008. The SNF or HHA providers reported on these claims define the complete post-acute referral network for a hospital.

We limited the follow-up period to 14-days following a patient's discharge to increase the likelihood that the post-acute care was related to the patient's hospitalization. The 14-day window is consistent with CMS's rules for coverage of home health services.<sup>14</sup> Using the 14-day rule, we include 52% of all HHA services and 92% of all SNF services that followed a hospital discharge in 2008. A total of 156 smaller hospitals were excluded from our study because they made no SNF or HHA referrals, or made referrals to only one type of post-acute provider.

Lastly, we distinguished between two types of post-acute providers within each hospital's referral networks: providers that accounted for more than 1% of the hospital's total annual post-acute provider referrals and providers that accounted for 1% or less. We refer to the former type of provider as "routine providers" and the latter as "low-volume providers". The 1% distinction was implemented primarily to identify post-acute provider referrals that likely deviated from a hospital's routine referral practices. Patients who received acute care while traveling or who traveled specifically for care at the hospital and subsequently obtained post-acute services near their home residence may explain many of the referrals to low-volume providers. Therefore, to provide a more conservative characterization of hospital post-acute referral networks, we focused only on the routine providers in our main analyses.

Network size was defined as the number of unique post-acute providers within each hospital's network. To characterize a hospital's network concentration we identified the top five SNF and HHA providers by the number of referrals received and tabulated the percent of the hospital's post-acute referrals covered by these five providers. We calculated this independently for both SNF and HHA providers. We also relied upon a normalized Hirschman–Herfindahl index (HHI) as an alternative measure of network concentration.<sup>15</sup> The results using the HHI were qualitatively similar ([Online Appendix, eTables 1 and 2](#)).

### 2.3. Analysis

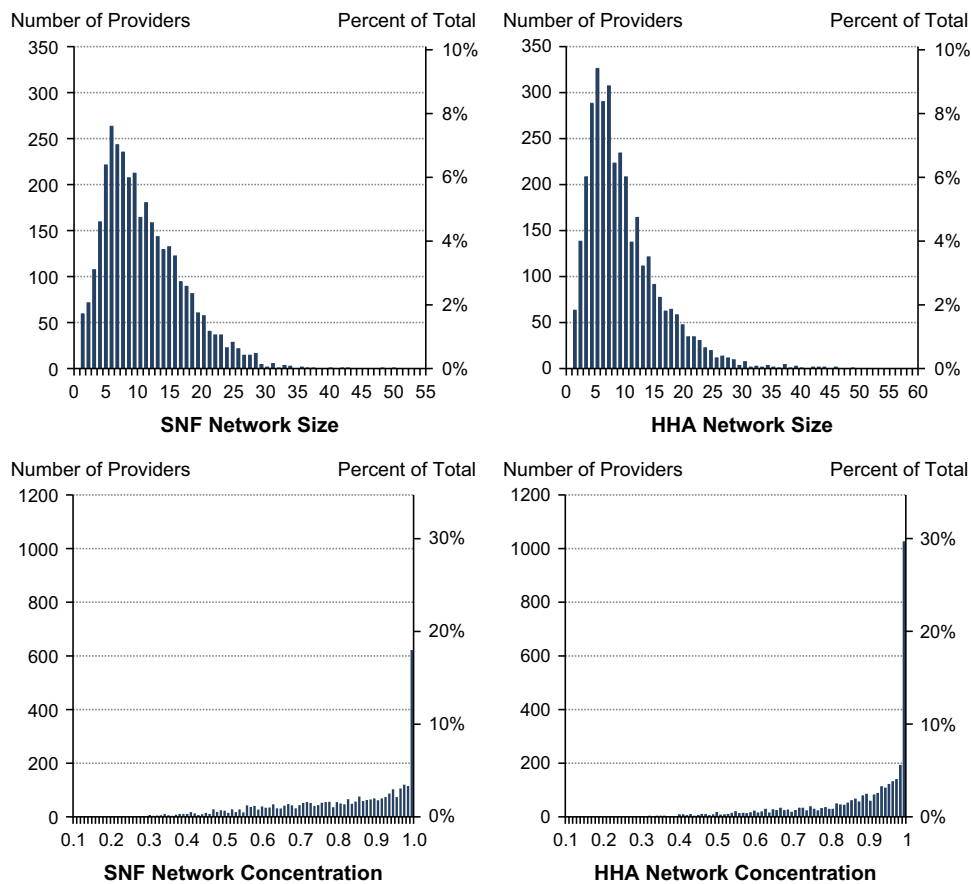
We generated summary statistics for SNF and HHA network size and concentration, and evaluated the variations across different hospital types and regional characteristics. We evaluated the association between hospital and regional characteristics on post-acute referral network size and concentration with a multivariate linear model. In order to understand the potential marginal effect of the covariates contained in our model, we used the recycled prediction method.<sup>16</sup> This method effectively allowed us to examine how average network size and concentration might differ if the population of hospitals differed along one dimension of hospital characteristics while holding all other characteristics the same. We presented the mean predicted values of network size and concentration at different values of the independent variable of interest.

**Table 1**  
Hospital post-acute care network size and referrals divided by routine versus low-volume providers.

	Skilled nursing facility			Home health agency		
	All referrals	Non-routine referrals <sup>a</sup>	Routine referrals <sup>a</sup>	All referrals	Non-routine referrals <sup>a</sup>	Routine referrals <sup>a</sup>
<b>Providers</b>						
Providers per Network, Mean	35	23 (65.7%)	12 (24.3%)	23	14 (60.9%)	10 (39.1%)
Total across nation	16,484	15,738 (95.5%)	14,955 (90.7%)	8870	8550 (96.4%)	7238 (81.6%)
<b>Referrals</b>						
Referrals per Hospital, Mean	430	49 (11.4%)	381 (88.6%)	271	26 (9.5%)	245 (90.5%)
Total across nation	1,494,389	169,725 (11.4%)	1,324,664 (88.6%)	941,104	89,092 (9.5%)	852,012 (90.5%)

Values are presented as mean (% of All SNF/HHA Providers Referrals). Providers within a hospital's referral network that received 1% or less of a hospital's referrals (non-routine referrals) were defined as a separate population of providers. Their respective post-acute care referrals within these networks were analyzed separately, as they most likely represented deviations from more routine post-acute care referrals.

<sup>a</sup> Providers that received 1% or less of a hospital's referrals were classified in this study as "non-routine". Routine referrals accounted for greater than 1 percent of a hospital's referrals.



**Fig. 1.** Distribution of hospital post-acute care network size and concentration, routine providers \*\* the sample presented excludes the referrals for providers that account for 1% or less of a hospital's total annual referrals. Concentration was defined as the percent of referrals received by the five most frequently referred providers in a hospital's post-acute referral network).

**3. Results**

In 2008, there were 1.5 million SNF referrals and .9 million HHA referrals across 3474 hospitals [Table 1]. The mean size of hospital post-acute referral networks was large, containing approximately 58 post-acute providers (34.5 SNFs and 23.4 HHAs). The majority of these post-acute providers (65.7% of SNFs, 60.9% of HHAs) were low-volume providers who accounted for 1 percent or less of a hospital's referrals. Referrals to low-volume providers comprised a modest fraction of all post-acute care referrals (11.4% of SNF referrals and 9.5% of HHA referrals). Excluding these low-volume

providers, the mean hospital post-acute referral network included 22 providers (11.7 SNFs and 9.6 HHAs).

Hospital referral network sizes for routine providers varied considerably, with the interquartile range of the number of post-acute providers in each network spanning from 6 to 16 providers for SNFs and 5–13 providers for HHAs [Fig. 1]. The percent of SNF and HHA referrals that were made to the top five providers in a hospital's referral network also varied across a large range. The interquartile range for the percent of referrals covered by the top five providers spanned from 68.6% to 97.4% for SNFs and from 81.3% to 100% for HHAs. For both SNF and HHA referral networks,

**Table 2**  
Size and concentration of hospital post-acute care referral networks for routine providers<sup>a</sup>, by hospital characteristics.

	Skilled nursing facility			Home health agency	
	Hospitals (N)	Network size (Mean ± SD)	Concentration <sup>a</sup> (Mean % ± SD)	Network size (Mean ± SD)	Concentration <sup>a</sup> (Mean % ± SD)
All	3474	11.7 ± 6.9	81.1% ± 17.9%	9.6 ± 6.5	87.6% ± 15.3%
<i>Hospital Size</i>					
< 100 Beds	1034	8.0 ± 5.6	91.1% ± 13.7%	7.5 ± 5.6	92.0% ± 12.7%
100–399 Beds	1855	12.2 ± 6.2	80.0% ± 16.2%	10.2 ± 6.6	86.6% ± 15.8%
> 399 Beds	443	18.7 ± 6.0	61.7% ± 15.8%	12.7 ± 6.2	81.6% ± 15.7%
<i>Location</i>					
Urban	3000	12.4 ± 6.8	79.2% ± 17.9%	10.2 ± 6.6	86.6% ± 15.6%
Rural	332	5.8 ± 2.9	97.1% ± 04.9%	5.4 ± 2.9	96.7% ± 05.9%
<i>Teaching Status</i>					
Teaching	279	20.5 ± 6.3	58.1% ± 14.8%	13.0 ± 6.1	80.6% ± 16.1%
Non-teaching	3053	11.0 ± 6.3	83.1% ± 16.6%	9.4 ± 6.4	88.3% ± 15.0%
<i>Ownership</i>					
For profit	712	11.2 ± 7.3	82.6% ± 18.1%	12.5 ± 8.1	79.7% ± 19.3%
Non-Gov, not-for-profit	2064	12.5 ± 6.4	78.9% ± 17.6%	9.1 ± 5.6	89.9% ± 12.7%
Government	556	9.8 ± 7.1	86.7% ± 17.1%	8.5 ± 6.2	89.4% ± 14.8%
<i>Medicaid discharge %</i>					
Below median (< 16.9%)	1666	11.8 ± 6.6	80.7% ± 17.3%	9.4 ± 6.1	88.4% ± 14.4%
Above median (> 16.9%)	1666	11.8 ± 7.0	81.3% ± 18.3%	10 ± 6.9	86.9% ± 16.6%

<sup>a</sup> Values are presented as mean ± SD for the sample that excludes the referrals for routine providers, those that account for 1% or less of a hospital's total annual referrals.

<sup>\*</sup> Concentration was defined as the percent of referrals received by the five most frequently referred providers in a hospital's post-acute referral network.

**Table 3**  
Size and concentration of hospital post-acute care provider referral network for routine providers<sup>a</sup>, by Hospital Region Characteristics.

	Skilled nursing facility			Home health agency	
	Hospitals (N)	Network size (Mean ± SD)	Concentration <sup>b</sup> (Mean % ± SD)	Network size (Mean ± SD)	Concentration <sup>b</sup> (Mean % ± SD)
All	3474	11.7 ± 6.9	81.1% ± 17.9%	9.6 ± 6.5	87.6% ± 15.3%
<i>Regions</i>					
Northeast	528	13.0 ± 6.2	76.1% ± 17.7%	7.0 ± 4.0	94.5% ± 08.8%
Midwest	748	14.1 ± 7.1	75.3% ± 18.4%	9.3 ± 6.2	90.1% ± 12.7%
South	1409	10.5 ± 6.6	84.7% ± 16.9%	11.1 ± 6.9	83.8% ± 16.8%
West	615	11.2 ± 6.4	82.7% ± 16.8%	9.5 ± 7.0	87.4% ± 16.1%
<i>Per capita inpatient spending in hospital referral region</i>					
Lowest quartile	621	10.6 ± 6.6	83.7% ± 17.7%	8.3 ± 6.2	90.4% ± 14.2%
2nd quartile	797	11.8 ± 6.6	81.0% ± 17.5%	9.2 ± 6.2	88.8% ± 14.2%
3rd quartile	913	11.8 ± 7.2	80.9% ± 18.4%	10.0 ± 6.5	86.8% ± 15.4%
Highest quartile	1104	12.4 ± 6.9	79.2% ± 17.8%	10.5 ± 6.9	85.9% ± 16.4%
<i>Per capita post-acute care spending in hospital referral region</i>					
Lowest quartile	581	10.6 ± 6.5	84.3% ± 17.0%	7.1 ± 4.8	93.6% ± 9.8%
2nd quartile	782	11.9 ± 6.4	80.8% ± 17.3%	7.9 ± 4.8	92.3% ± 10.8%
3rd quartile	967	12.4 ± 6.9	79.0% ± 18.4%	9.0 ± 5.4	90.0% ± 12.5%
Highest quartile	1105	11.9 ± 7.3	80.8% ± 18.3%	12.9 ± 7.9	79.1% ± 18.7%

<sup>a</sup> Values are presented as mean ± SD for the sample that excludes the referrals for providers that account for 1% or less of a hospital's total annual referrals.

<sup>b</sup> Concentration was defined as the percent of referrals received by the five most frequently referred providers in a hospital's post-acute referral network.

more than 10% of hospitals referred all their patients to just one provider.

The size of hospital post-acute referral networks for routine providers varied across hospital characteristics [Table 2]. On average, hospitals with ≥ 400 beds had larger referral networks than hospitals with < 100 beds (30.4 vs. 15.5 providers,  $P < .001$ ). The average network size was also larger for urban hospitals than rural hospitals (22.6 vs. 11.1 providers,  $P < .001$ ) and for for-profit hospitals compared with government-owned hospitals and not-for-profit hospitals (23.7 vs. 18.3 providers,  $P < .001$ ; 23.7 vs. 21.6 providers,  $P < .001$ ). Teaching hospitals also had larger post-acute referral networks for routine providers than their non-teaching counterparts (33.5 vs. 20.4 providers,  $P < .001$ ).

Network concentration also varied by hospital characteristics. Compared to those with < 100 beds, hospitals with ≥ 400 beds

referred, on average, a smaller fraction to their top five providers (61.7% vs. 91.1% of SNF referrals,  $P < .001$ ; 81.6% vs. 92.0% of HHA referrals,  $P < .001$ ). Teaching hospitals had less concentrated SNF referral networks than their non-teaching counterparts (58.1% vs. 83.1% of SNF referrals,  $P < .001$ ).

Both the size and concentration of hospital post-acute referral networks varied across Census regions and HRRs [Table 3]. The Midwest had the largest and least concentrated average SNF provider referral networks (14.1 providers, 75.3% of referrals covered by top five providers). Hospitals in the South had, on average, larger and less concentrated HHA provider referral networks (11.1 providers, 83.8% of referrals covered by top five providers). Hospitals located in HRRs within the lowest quartile of post-acute per capita spending had smaller referral networks (17.7 vs. 24.8 providers,  $P < .001$ ). The top five providers also

**Table 4**  
Predicted Mean Hospital Network Size and Concentration for Routine Providers,<sup>a</sup> Controlling for Hospital and Regional Characteristics.

	Skilled nursing facility				Home health agency			
	Network size		Concentration		Network size		Concentration	
	N	P-value	N (%)	P-value	N	P-value	N (%)	P-value
<i>Hospital Size</i>								
< 100 Beds	8.9	[Ref]	89.0	[Ref]	7.6	[Ref]	92.0	[Ref]
100–399 Beds	12.3	< .001	79.7	< .001	10.4	< .001	86.2	< .001
> 399 Beds	16.8	< .001	66.5	< .001	12.0	< .001	82.9	< .001
<i>Location</i>								
Rural	9.0	[ref]	88.1	[ref]	6.8	[ref]	94.1	[ref]
Urban	12.1	< .001	80.1	< .001	10.1	< .001	86.9	< .001
<i>Teaching Status</i>								
Non-Teaching	11.4	[ref]	82.0	[ref]	9.5	[ref]	88.2	[ref]
Teaching	16.9	< .001	68.7	< .001	12.5	< .001	80.9	< .001
<i>Ownership</i>								
For Profit	12.8	[ref]	78.3	[ref]	11.8	[ref]	81.7	[ref]
Non-Gov, Not-for-profit	11.8	.005	80.9	.006	9.4	< .001	89.0	< .001
Government	10.7	< .001	84.2	< .001	8.5	< .001	89.8	< .001
<i>% Medicaid<sup>b</sup></i>								
Below Median (< 16.9%)	12.2	< .001	79.4	< .001	9.8	.468	87.2	.211
Above Median (> 16.9%)	11.4		82.4%		9.6		88.0	
<i>HRR PAC Spending</i>								
Lowest quartile	10.6	[ref]	85.1	[ref]	6.6	[ref]	95.0	[ref]
2nd quartile	11.6	.033	81.7	.009	8.0	.008	91.8	.015
3rd quartile	11.8	.008	80.5	< .001	9.6	< .001	88.5	< .001
Highest quartile	12.7	< .001	78.5	< .001	12.7	< .001	79.9	< .001

<sup>a</sup> The predictions presented are based on the recycled predictions methodology on the sample that excludes the referrals for providers that account for 1% or less of a hospital's total annual referrals. The regression also controlled for hospital discharge rates, HRR inpatient spending, and HRR quality measures for hospital care.

<sup>b</sup> The proportion of hospital discharges that were covered by Medicaid was included in the regression as a continuous variable.

represented a larger proportion of referrals for hospitals in the lower quartile of post-acute per capita spending (84.3% vs. 80.8% of SNF referrals,  $P < .001$ , 93.6% vs. 79.1% of HHA referrals,  $P < .001$ ).

In our multivariate regression, after controlling for other observable covariates, the variation in network size and concentration associated with hospital and regional characteristics persists. Adjusting for all other covariates including size, teaching hospitals had a higher mean predicted network size relative to non-teaching hospitals (16.9 vs. 11.4 SNF providers,  $P < .001$ ; 12.5 vs. 9.5 HHA providers,  $P < .001$ ) [Table 4]. For-profit hospitals showed a larger mean predicted network size than not-for-profit hospitals and government-owned hospitals (12.8 vs. 11.8 vs. 10.7 SNF providers,  $P < .01$ ; 11.8 vs. 9.4 vs. 8.5 HHA providers,  $P < .001$ ). Lastly, hospitals in the highest quartile of post-acute care spending produced a larger mean predicted network size versus hospitals in the lowest quartile of post-acute care spending (12.7 vs. 10.6 SNF providers,  $P < .001$ ; 12.7 vs. 6.6 HHA providers,  $P < .001$ ).

#### 4. Discussion

New payment models like those piloted in the Medicare Bundled Payment Care Improvement initiative reward coordination between acute and post-acute providers. In response to the incentives created by these new payment systems, hospitals will likely increase their selectivity in both how often and where they refer patients for post-acute care. Our study of the current referral patterns of hospitals highlights some of the complexities likely to shape these responses. The average hospital post-acute referral network is large, particularly among larger hospitals and teaching hospitals. While post-acute referral networks also tend to be highly concentrated—most hospitals refer the majority of post-acute services to a small number of providers—the majority of

post-acute providers in a hospital's referral network individually account for less than 1% of a hospital's referrals.

Under new bundled payment models, hospitals will likely attempt to better integrate care with the small number of post-acute providers that account for the majority of the hospital's referrals. This integration could focus on better communication using electronic health records and communications at the time of transfer.<sup>17,18</sup> Integration could also occur through contractual arrangements. Hospitals might acquire post-acute providers or create preferred provider referral networks. Indeed this might already be the case; one limitation of our study is an inability to discern whether hospitals and post-acute providers are under a single financial entity. Hospitals may also choose to concentrate their referrals among a smaller group of post-acute providers, a strategy with potential implications for the competitive environment faced by post-acute providers. Previous Federal anti-kickback laws limited preferred referral networks and gain sharing agreements, but waivers have been issued to relax these restrictions for providers participating in new bundled payment initiatives.<sup>19</sup>

A key complexity that hospitals may face is how to address post-acute providers that account for a small number of referrals. More than half of post-acute providers receive less than 1% of one or more of a hospital's total annual post-acute care referrals, often just one case in a given year. These might represent unique circumstances in which a patient lives far away from the hospital where they received care. While these low-volume providers account for only one in 10 referrals, hospitals will face a difficult tension in these situations. Even though a given post-acute provider may account for few patients, a small number of inefficient post-acute providers might undermine a hospital's ability to save money under bundled payment. A hospital might prefer that the patient goes to a post-acute provider which is better integrated with the hospital given that

hospitals are financially responsible for this care.<sup>20</sup> However, hospitals are prohibited from limiting patient access to providers by CMS. This policy creates a tension where hospitals have financial responsibility for care delivered by post-acute providers, but are limited in their ability to direct patients to efficient providers.

Hospitals in regions with lower post-acute care spending have smaller, more concentrated networks. In a descriptive study, we cannot establish a causal link between the size and concentration of a hospital's post-acute care network and a hospital's post-acute care spending. However, the observed pattern is consistent with the idea that reducing post-acute costs reduction may require hospitals to concentrate their referrals among a smaller set of post-acute providers.

Our study has several key limitations that may be addressed through additional research. Firstly, in this descriptive study we examine how networks vary by hospital and regional characteristics, but cannot evaluate the causal effect of these factors on network size and concentration. Secondly, we do not account for the variations in the “choice set” of post-acute providers to which each hospital is able to refer patients. The availability of post-acute providers in individual markets is likely to influence network size and concentration. Some of the variation we see in referral networks across types of hospitals may be driven by the availability of post-acute providers rather than the procedures employed by hospitals to make post-acute referrals. And while we focus on post-acute referrals from the perspective of hospitals, it is important to recognize that patients and physicians play critical roles in choosing post-acute providers. Thirdly, we do not identify whether hospitals own post-acute care facilities or whether multiple post-acute care facilities are owned by a single entity. The degree of existing integration and market concentration are likely to affect the magnitude of the challenges that hospitals will experience. Fourthly, our study does not focus on what fraction of a hospital's patients receives post-acute care or the relative intensity of different types of post-acute care. Optimizing the volume and type of post-acute care will likely become another major area of focus for hospitals under new bundled payment systems. Lastly, our study is limited to SNF and HHA provider referral networks and Medicare patients over 65, and therefore underestimates the total size of a hospital's post-acute network. While SNF and HHA are the most commonly used post-acute providers, future studies may consider other post-acute providers such as rehabilitation hospital's and long-term care hospitals, and examine non-Medicare patients.

Considerable attention has been given to the potential cost savings achievable under new bundled payment models that encourage more prudent use of post-acute care and better coordination between hospitals and post-acute providers. However, relatively little consideration has been given to these models' potential implementation barriers for hospitals and post-acute providers. Our study of hospital post-acute care referral networks suggests that hospitals will face difficulties coordinating care given the large number of post-acute providers in a hospital's network. In particular, coordination may be difficult with the large number of post-acute providers that account for a small number of referrals. If hospitals located in low spending regions are any indication of the future, pressures under bundled payment may push hospitals to reduce the size and increase the concentration of

their post-acute referral network. This may drive increased financial integration between hospitals and post-acute providers. What impact these changes have on clinical outcomes, patient satisfaction, and healthcare spending remain to be seen.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.hjdsi.2014.05.004>.

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