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# Hospitals serving nursing home residents disproportionately penalized under hospital readmissions reduction program

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## Abstract

**Background:** Risk factors common to nursing home (NH) residents are potentially not fully captured by the Hospital Readmissions Reduction Program (HRRP). The unique challenges faced by hospitals that disproportionately serve NH residents who are at greater risk of readmissions have not been studied.

**Methods:** Using 100% Medicare Provider Analysis and Review File and the Minimum Data Set from 2010–2013, we constructed a measure of hospital share of NH-originating hospitalizations (NOHs). We defined hospital share of NOHs as the proportion of inpatient stays by patients aged 65 or older who were directly admitted from NHs. To evaluate the impact of the share of NOHs on readmission penalties, we categorized hospitals into quartiles according to their share of NOHs and estimated the differences in the adjusted penalties across hospital quartiles after accounting for hospital characteristics, market characteristics and state fixed effects. We repeated the analyses for the penalties incurred in each year between 2015 and 2019.

**Results:** Hospitals varied substantially in the share of NOHs (median [interquartile range], 11.3% [8.2%–15.1%]), with limited variation over time. In 2015, hospitals in the highest quartile of NOH received on average 0.58% Medicare payment reduction compared to 0.44% reduction among those in the lowest quartile (32.9% higher penalties,  $p < 0.001$ ). The increase in penalties continued to grow in 2017 and 2018 when the HRRP expanded to include additional target conditions (47.3% and 66.7%, respectively,  $p < 0.001$  for both). Although the effect diminished in 2019 following the additional adjustment for hospital's dual-eligible share, hospitals in the highest quartile of NOH still incurred 43.0% ( $p < 0.001$ ) higher penalties than those in the lowest quartile.

**Conclusions:** Hospitals varied considerably in their share of NOHs. Hospitals having a higher share of NOHs were disproportionately penalized for excess

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readmissions, even under the revised policy that adjusts for the share of dual-eligible admissions.

#### KEYWORDS

care coordination, Hospital Readmissions Reduction Program, nursing home residents, quality improvement, risk adjustment

## INTRODUCTION

Since October 1, 2012, hospitals have been penalized for excess readmissions under the Hospital Readmissions Reduction Program (HRRP) through reduction in Medicare reimbursement.<sup>1</sup> In each year, about 79% of US hospitals were penalized with total penalties amounting to as high as \$528 million.<sup>2</sup> Identifying hospitals at increased risk for excess readmission rates and understanding factors that contribute to poorer hospital performance under the HRRP have become a major priority for both the hospital industry and policymakers.

Studies have found that hospitals serving the most medically complex and socioeconomically disadvantaged patients tended to have higher readmission rates, and persistently bore higher amount of penalties.<sup>2-6</sup> These studies focused on minority, low-income, and Medicare and Medicaid dually eligible patients. Nevertheless, even among hospitals largely serving these vulnerable patients, there are considerable variations in readmission rates,<sup>7,8</sup> suggesting that focusing on these commonly studied vulnerable patient groups may not be sufficient to identify hospitals at the highest risk for readmission penalties.

The unique challenges faced by hospitals that disproportionately serve nursing home (NH) residents, who are at greater risk of readmissions,<sup>9-13</sup> have not been studied. Readmission risk factors for this population are not well captured in the current HRRP risk adjustment methodology that adjusts for only age, gender, and comorbidities.<sup>14</sup> Beginning on October 1, 2018, the HRRP has implemented a revised methodology that further adjusts for hospital share of admissions by dual-eligible patients.<sup>15</sup> Important factors such as cognitive and functional impairment that are particularly prevalent among NH residents,<sup>16</sup> remain inadequately adjusted for. These factors have been shown to independently increase the risk of rehospitalizations even after accounting for patient demographics, socioeconomic status, and comorbidities.<sup>17-19</sup> To the degree that these important risk factors are not adequately adjusted for, hospitals that disproportionately serve patients beset by these factors (e.g., NH residents) may appear to provide worse care.

To our knowledge, no study has investigated whether, and to what extent, hospitals vary in their share of admissions of NHs residents (NH-originating hospitalizations,

### Key points

- Hospitals varied substantially in the share of NH-originating hospitalizations (NOHs).
- NOHs disproportionately affected hospitals that were for-profit, had lower registered nurse staffing, had lower occupancy rates, and had a higher share of low-income patients.
- A higher share of NOHs was independently associated with higher readmission penalties under various HRRP scenarios, even under the revised policy that adjusts for the share of Medicare and Medicaid dual-eligible admissions.

### Why does this paper matter?

Hospitals serving NH residents are disproportionately penalized for excess readmissions and may endure unintended clinical and financial consequences of the HRRP program.

NOHs) and whether hospitals that disproportionately serve this population systematically differ from other hospitals and are more likely to be penalized for readmissions. The objectives of this study were to: (1) describe the variation in hospital share of NOHs; (2) explore hospital and market characteristics associated with higher hospital share of NOHs; and (3) examine whether hospitals with higher share of NOHs were disproportionately penalized under the HRRP program.

## METHODS

### Data

We employed the following data sources: Medicare Beneficiary Summary File (MBSF), which contains demographic and monthly enrollment information for all Medicare beneficiaries; Minimum Data Set (MDS) nursing home resident assessments, which include clinical information for all

residents receiving care in Medicare/Medicaid-certified NHs, with data collected at admission and discharge and at regular intervals during NH stays; 100% Medicare Provider Analysis and Review File (MedPAR), which includes discharge abstracts of inpatient and skilled nursing facilities (SNF) stays for all fee-for-service (FFS) Medicare beneficiaries. These data sources were merged to identify Medicare beneficiaries who resided in NH prior to hospitalization. Data on hospital and market characteristics were obtained from the Provider of Services File, Medicare Impact File, Certification and Survey Provider Enhanced Reporting data (CASPER) and Area Health Resources File (AHRF). Data from CY 2010–2013 were used to identify hospitals that disproportionately served NH residents and to examine the characteristics of these hospitals. HRRP supplemental data files for fiscal years (FY) 2015–2019 were used to examine readmission penalties under various HRRP policy scenarios. We focused on the payment period of FYs 2015–2019 because this timeframe captured the major changes of the HRRP program (e.g., an expansion to include Coronary Artery Bypass Grafting surgery in FY2017 and changes in risk adjustment method to additionally adjust for dual-eligible share in FY2019).<sup>15</sup>

## Study population

This study focused on non-federal, general, short-term, acute care hospitals in all 50 states and the District of Columbia with HRRP data. At the patient level, we included all FFS Medicare beneficiaries aged 65+ who were discharged from these hospitals between July 1, 2010 and June 30, 2013 (the performance period of the readmission penalty for 2015). Based on these criteria, a total number of 24,963,717 Medicare patient admissions were identified in the 3399 HRRP-participating hospitals.

We excluded hospitals with fewer than 50 beds because these small hospitals may not have enough admissions to reliably measure NOH. The resulting analytic cohort comprised 2868 hospitals and 24,340,402 Medicare admissions (97.5% of all eligible admissions in the 84.4% eligible hospitals).

## Variables

### *Hospital share of NOHs*

We defined hospital share of NOHs as the proportion of inpatient stays by patients aged 65 or older who were directly admitted from NHs between 2010 and 2013. They included both short-stay and long-stay residents. We considered a patient to be admitted from NH if he/she was hospitalized within 2 days of discharge from a NH, based

on the MDS discharge assessment; or if he/she had a quarterly or annual MDS assessment within 100 days of hospitalization if discharge assessment was missing (approximately 1.4% of NOHs). Consistent with CMS methodology in dealing with multiple contiguous hospitalizations,<sup>20</sup> we considered transfers to another hospital (0.8% of admissions) part of a single episode. Therefore, we considered the second hospital stay during a transfer as NOH if the first stay originated from a NH.

## Hospital readmission penalty

We derived readmission penalties from the HRRP payment adjustment factors for FYs 2015–2019. We included data beyond 2015 to examine the impact of the share of NOHs under various HRRP policy scenarios.<sup>15</sup> We calculated the penalty as percent reduction in the base Diagnosis-Related Group (DRG) payments on all Medicare inpatient admissions, which ranged from 0% to 3%.

## Hospital and market characteristics potentially associated with hospital share of NOHs

### *Hospital characteristics*

We focused on variables that may influence hospital share of vulnerable patients<sup>4,21,22</sup> and factors known to predict hospital readmission rates<sup>3,23</sup>: hospital bed size, ownership, medical school affiliation, ownership of any NHs (a measure of the referral threshold between hospitals and NHs<sup>22</sup>), occupancy rate (a measure of the cost of delaying or denying admissions<sup>24</sup>), Disproportionate Share Hospital index (a measure of the share of low-income patients), Medicare case-mix index (the average DRG relative weights over all Medicare discharges).

### *Market characteristics*

We included the following county-level market characteristics: number of NH residents per 1000 population aged 65+; number of acute hospital beds per 1000 population; rural/urban location; hospital competition measured by the Herfindahl–Hirschman Index (HHI), calculated as the sum of squared market share (beds) among all hospitals in the county. These factors characterize key aspects of the external environment that may influence the proportion of patients likely to be hospitalized from NHs versus from the community, the supply of hospital services in the market, and market conditions that may influence hospitals' strategies to compete for patients. Hospitals in more competitive environments may have stronger incentives to compete for patients, including those whose care may be more challenging.

## Analyses

All analyses were conducted at the hospital level. To examine whether hospitals that disproportionately serve NH residents systematically differ from other hospitals, we first categorized hospitals into quartiles of the share of NOH and compared the characteristics across quartiles (unadjusted). To identify the characteristics associated with the share of NOHs, we employed generalized linear model (GLM) with binomial distribution and logit link function, in which the conditional mean of  $p$ , the proportion of hospital admissions that were NOHs, was directly modeled without transformation. We included state fixed effects to control for any unobserved heterogeneity across states, such as state Medicaid policies that may influence both the share of NOHs and the overall readmission rates. Results are displayed as marginal effects using coefficient estimates from the multivariate GLM model.

To evaluate the association between the share of NOHs and readmission penalties (percent and total reduction in base Medicare payment), we estimated the predicted penalties for each quartile after accounting for hospital characteristics, market characteristics and state fixed effects. Because the readmission penalties in percent reduction were bounded between 0% and 3%, we rescaled the variable to the interval [0, 1] and predicted the adjusted penalties using GLM with binomial distribution and logit link function. We then obtained the predicted penalty in aggregate amount by multiplying the margins with the aggregated base DRG payment in each hospital quartile. We repeated the analyses for each year 2015–2019. Analysis for aggregated penalties were conducted for 2015–2016 because data were available for this period only (Data S1 for details).

We performed several sensitivity analyses to examine the robustness of our main findings. First, we used different cut-points for the interval between hospital admission date and the most recent NH discharge date (e.g., 7 days vs. 2 days). Second, in the main analysis, we extrapolated the HRRP effects to fiscal years beyond 2015 assuming hospital share of NOHs is stable over time. To test this assumption, we constructed measures separately for each 12-months performance period during 2010–2013 and calculated their correlations with each other. Third, to examine if the association with readmission penalty was due to disproportionate share of other vulnerable patients, we further adjusted for hospital share of minority and dual-eligible admissions. Fourth, to mitigate the potential confounding by the unobserved managerial relationship between hospital-based NHs and their parent hospitals, we reevaluated the effects excluding hospitals that owned NHs as identified in the CASPER data.

## RESULTS

### Sample characteristics

Among the 24,340,402 hospital stays identified, 2,730,566 (11.2%) were found to have originated from NHs. Patients whose admission originated from NHs were statistically significantly older (median age, 82- vs. 77- year-old,  $p < 0.001$ ), more likely to be female (62.4% vs. 56.7%), African Americans (14.5% vs. 9.4%), had longer length of stays (median days, 5 vs. 4 days) and were more likely to have  $\geq 3$  comorbidities (75.6% vs. 56.2%) (Table S1).

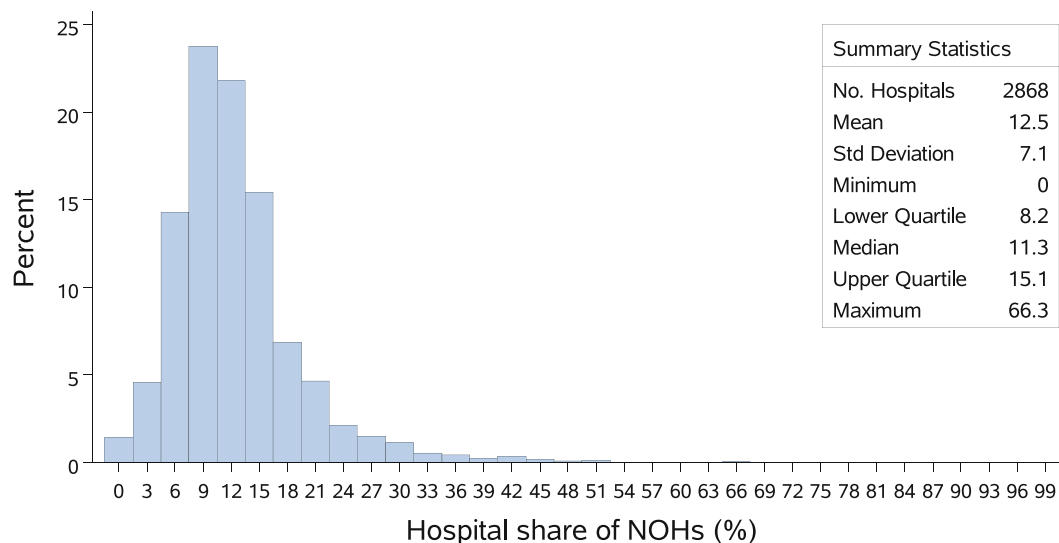
Overall, NOHs were less likely to have a principal diagnosis of the HRRP target conditions than admissions from the community (19.1% vs. 22.0%,  $p < 0.001$ ), primarily due to fewer admissions for the target surgical procedures (Table S1).

### Variation in hospital share of NOHs according to hospital and market characteristics

At the hospital level, the share of NOHs varied from 0 to 66.3% (median [IQR], 11.3% [8.2%–15.1%]) (Figure 1). Hospitals that had the highest share of NOHs were more likely to be smaller facilities, for-profit, having ownership of NH, not affiliated with medical school. These hospitals also tended to have more low-income patients, lower occupancy rates, lower Medicare case-mix index, and lower registered nurse staffing. These hospitals tended to serve markets with lower median household income and markets in rural areas (Table 1). Results were similar when adjusting for covariates, except for bed size, ownership of NHs, medical school affiliation, and the direction of the association with rural location. For example, hospitals having the highest share of low-income patients had, on average, 2.96% ( $p < 0.001$ ) higher share of NOHs than hospitals having the lowest share of low-income patients. Hospitals with lower nurse staffing had higher share of NOHs (on average 0.9% higher rates per SD decrease in nurse staffing,  $p < 0.01$ ). After controlling for covariates, hospitals that serve rural markets had 0.73% lower share of NOHs ( $p < 0.01$ ) (Table 2).

### Association between the share of NOHs and readmission penalties

In multivariate analyses, hospitals with higher shares of NOHs, especially those in the highest and the second highest quartiles, were disproportionately penalized throughout the period during 2015–2019 (Figure 2A). For instance, in 2015, hospitals in the highest quartile of



**FIGURE 1** Distribution of hospital share of nursing home-originating hospitalizations (NOHs) among hospitals with over 50 beds, July 2010–June 2013. Source Authors' analysis of Medicare Provider Analysis and Review files, Minimum Data Set, Provider of Services files, 2010–2013

NOH received on average 0.58% Medicare payment reduction compared to 0.44% reduction among those in the lowest quartile (32.9% higher penalties,  $p < 0.001$ ). The penalty difference between the highest and lowest quartiles continued to grow in 2017 and 2018 when the HRRP expanded to include additional target conditions (47.3% and 66.7%, respectively,  $p < 0.001$  for both). Although the effect diminished in 2019 following the additional adjustment for dual-eligible share, hospitals in the highest quartile of NOH still incurred 43.0% ( $p < 0.001$ ) higher penalties than those in the lowest quartile. The base Medicare payment rates for high-NOH hospitals were substantially lower than the rates for other hospitals (Table S2), resulting in greater payment reduction in aggregate amount (Figure 2B).

### Sensitivity analyses

Adopting alternative time cut-points to define NOH had little impact on the distribution of hospital share of NOHs (Figure S1). We found the measure of hospital share of NOHs were highly stable over time, with correlation coefficients all above 0.93 between any two performance periods during 2010–2013 (Table S3). Adjusting for the proportion of admissions of other vulnerable patient population did not alter the higher penalties among high-NOH hospitals (Figure S2). Moreover, the effects of NOHs were stronger than minority and dual-eligible admissions in all years except for 2015 (Tables S4–S8). Results remained essentially unchanged after excluding hospitals that owned NHs (Figure S3).

### DISCUSSION

This study quantified the hospital share of NH-originating hospitalizations (NOHs) and examined the relationship between NOHs and hospital readmission penalties. We found substantial variations across hospitals in the share of NOHs. Hospitals with the highest share of NOHs were disproportionately penalized under the current HRRP policy, even after adjusting for hospital share of dual-eligible admissions. To our knowledge, this is the first study to examine hospitals' share of admissions of NH residents and the association with readmission penalties. Findings from this study are especially relevant in the context of the continuous redesign of the HRRP policy and have important implications for the acute care delivery to older adults admitted from NHs.

Higher penalties among hospitals that disproportionately served NH residents may capture a lack of adjustment of additional risks inherent among the frail NH residents, system-level factors such as limited access to high-performing NHs, or suboptimal care provided at these hospitals.

Prior research suggested that the observed differences in hospital readmission rates remain largely explained by the unequal distribution of patients' clinical and social characteristics that are predictive of readmission risks.<sup>17</sup> A recent study indicated that stratifying hospitals by their share of dual-eligible admissions considerably shifted the penalties away from hospitals that tended to serve disadvantaged populations and neighborhoods.<sup>25</sup> The current HRRP provides limited adjustment for important clinical risk factors that disproportionately affect NH residents

TABLE 1 Comparison of hospital and market characteristics across hospital quartiles

Variables	Overall	Hospital quartiles of the share of NOHs				p-value <sup>a</sup>
		1st quartile (lowest)	2nd quartile	3rd quartile	4th quartile (highest)	
Number of hospitals	2868	717	717	717	717	—
Percentage share of NOHs, median [IQR]	11.3 [8.2, 15.1]	6.1 [4.6, 7.3]	9.7 [9.0, 10.4]	13.0 [12.0, 14.0]	19.2 [16.5, 23.8]	—
<i>Hospital characteristics</i>						
Number of hospital beds, %						<0.001
51–100	22.2	20.5	15.0	20.6	32.8	
101–200	29.5	27.2	26.5	30.1	34.1	
201–300	17.6	17.6	17.2	19.5	15.9	
> 300	30.7	34.7	41.3	29.7	17.2	
<i>Hospital ownership, %</i>						
Not for profit	65.2	62.9	70.0	69.3	58.7	<0.001
For profit	18.8	19.0	15.5	16.5	24.4	
Government	15.9	18.1	14.5	14.2	16.9	
<i>Ownership of any NH, %</i>						
No	81.7	88.3	81.6	79.2	77.8	<0.001
Yes	18.3	11.7	18.4	20.8	22.2	
<i>Medical school affiliation, %</i>						
No	64.9	59.1	59.7	67.6	72.9	<0.001
Yes	35.2	40.9	40.3	32.4	27.1	
<i>Disproportionate share index, median [IQR]</i>						
	0.26 [0.19, –0.36]	0.25 [0.15, 0.36]	0.25 [0.19, 0.33]	0.26 [0.19, 0.34]	0.30 [0.21, 0.43]	<0.001
<i>Occupancy rate, median [IQR]</i>						
	54.0 [40.4–65.1]	57.9 [44.6, 67.4]	57.6 [46.3, 66.8]	54.2 [40.4, 64.5]	44.9 [31.9, 59.2]	<0.001
<i>Medicare hospital case-mix index, median [IQR]</i>						
	1.5 [1.3–1.6]	1.6 [1.4, 1.8]	1.5 [1.4, 1.7]	1.4 [1.3, 1.6]	1.3 [1.2, 1.5]	<0.001
<i>Hospital RN staffing, median [IQR]</i>						
	102.1 [72.6–138.5]	117.3 [83.0, 156.9]	111.5 [80.9, 143.3]	103.7 [74.6, 137.7]	80.3 [56.3, 112.7]	<0.001
<i>Market characteristics</i>						
<i>NH residents per capita 65+ (X 1000), median [IQR]</i>						
	40.1 [30.2–51.8] <sup>b</sup>	28.6 [20.6, 38.7]	37.0 [27.6, 46.6]	41.4 [33.2, 51.4]	45.7 [33.7, 55.2]	<0.001
<i>Median household income (in \$1000), median [IQR]</i>						
	44.1 [38.5–52.2] <sup>b</sup>	50.1 [43.8, 58.3]	48.1 [42.0, 56.0]	47.2 [41.3, 54.1]	44.6 [38.1, 53.1]	<0.001
<i>Hospital beds per 1000 population, median [IQR]</i>						
	2.6 [1.7–3.9] <sup>b</sup>	2.5 [1.8, 3.5]	2.8 [1.9, 4.1]	2.8 [1.9, 3.9]	2.7 [1.9, 3.8]	0.037
<i>Rural location, %</i>						
No	56.8 <sup>b</sup>	90.0	83.3	73.4	63.9	<0.001
Yes	43.2 <sup>b</sup>	10.0	16.7	26.6	36.1	

(Continues)

TABLE 1 (Continued)

Variables	Hospital quartiles of the share of NOHs				p-value <sup>a</sup>
	Overall	1st quartile (lowest)	2nd quartile	3rd quartile	
Market concentration, %					<0.001
Concentrated (HHI $\geq$ 0.15)	97.2 <sup>b</sup>	75.5	83.7	81.0	75.6
Unconcentrated (HHI < 0.15)	2.8 <sup>b</sup>	24.6	16.3	19.0	24.4

Abbreviations: HHI, Herfindahl–Hirschman Index; IQR, interquartile range; NH, nursing home; NOH, nursing home-originating hospitalization; RN, registered nurse.

<sup>a</sup>p-value was calculated using Kruskal–Wallis Test for continuous variables or  $\chi^2$  test for categorical variables.

<sup>b</sup>The overall distribution of these variables for market characteristics was calculated at the county-level. The distribution in each hospital quartile was calculated at the hospital level.

such as cognitive impairment and functional disability.<sup>16</sup> Specifically, functional impairment is measured by the presence of severe physical disabilities (e.g., paralysis and paraplegia),<sup>14</sup> which may only capture a small proportion of residents with functional dependency.<sup>16</sup> Cognitive status is primarily captured by a group of dementia-related diagnoses using claims records,<sup>14</sup> which may underestimate comorbid dementia<sup>26</sup> and may omit other cognitive impairment.<sup>16</sup> Although the revised policy additionally adjusts for hospital share of dual-eligible admissions, the impact of such clinical factors may still exist as they disproportionately affect institutionalized older adults residing in NHs<sup>16</sup> of whom fewer than half were dually eligible in our study. The persistent greater penalties among high-NOH hospitals, even after controlling for hospital share of dual-eligible admissions, suggest that NOH status might capture additional factors beyond dual-eligible status.

Moreover, NH residents may be at a higher risk of readmission due to poor care coordination between hospitals and NHs.<sup>9</sup> One study reported that NH residents had three times higher risk of 30-day readmissions following an Acute Myocardial Infarction than their community counterparts even after race, dual-eligible status, functional and cognitive status were accounted for, suggesting that additional system-level factors may play a role.<sup>13</sup> Another study reported that over 10.4% of SNF stays did not have any physician or nurse practitioner visits after hospital discharge,<sup>27</sup> an effective strategy to prevent readmissions.<sup>28</sup> Medicare reimbursement for transitional care management (e.g., medication reconciliation, review of discharge information, follow-ups on pending diagnostic tests) only applies to patients discharged to the community.<sup>29</sup> The fragmented care between hospitals and NHs<sup>30,31</sup> may disproportionately affect patients originating from NHs because of their frequent transfers between these care settings.<sup>32–35</sup>

Hospital share of NOHs may also capture a hospital's access to high-performing NHs in its local market. Approximately 92.6% of long-stay NH residents return to their previous NHs after hospitalization to maintain continuum of care.<sup>32</sup> Hospitals with a high share of NOHs may discharge a considerable proportion of their patients back to their previous NHs, which may not necessarily be high-performing NHs in the neighborhood. An increasing amount of evidence has highlighted the importance of NH quality in preventing rehospitalizations.<sup>36–38</sup> However, it may not be feasible for hospitals to discharge patients to high-performing NHs, either due to a lack of empty beds in those NHs or residents' expectation to remain in their “home”, regardless of its quality.

Finally, we cannot rule out the possibility that NH residents receive care in hospitals that provide poorer



**TABLE 2** Hospital and market characteristics associated with the percentage share of nursing home-originating hospitalizations, among hospitals with over 50 beds, July 2010–June 2013

Independent variables	Marginal effects <sup>a</sup>	p-value
<i>Hospital characteristics</i>		
Number of hospital beds		0.736 <sup>b</sup>
51–100	(Ref)	
101–200	–0.03	0.911
201–300	0.09	0.802
>300	–0.18	0.605
Ownership of any NH		0.064
No	(Ref)	
Yes	0.38	
Hospital ownership		<0.001 <sup>b</sup>
Not for profit	(Ref)	
For profit	0.91	<0.001
Government	–0.44	0.044
Medical school affiliation		0.284
No	(Ref)	
Yes	–0.20	
Disproportionate share index		<0.001 <sup>b</sup>
1st quartile (lowest)	(Ref)	
2nd quartile	1.08	<0.001
3rd quartile	1.62	<0.001
4th quartile (highest)	2.96	<0.001
Occupancy rate		<0.001 <sup>b</sup>
1st quartile (lowest)	(Ref)	
2nd quartile	–1.00	<0.001
3rd quartile	–1.23	<0.001
4th quartile (highest)	–0.88	0.007
Medicare hospital case-mix index	–2.28 <sup>c</sup>	<0.001
Medicare hospital case-mix index squared		0.077
Hospital RN staffing	–0.90 <sup>c</sup>	0.008
Hospital RN staffing squared		0.006
<i>Market Characteristics</i>		
NH residents per capita 65+ (X 1000)	1.96 <sup>c</sup>	<0.001
NH residents per capita 65+ (X 1000) squared		<0.001
Median household income (in \$1000)	–0.29 <sup>c</sup>	0.110
Median household income (in \$1000) squared		0.056
Hospital beds per 1000 population	–0.64	<0.001
Rural location		0.004
No	(Ref)	
Yes	–0.73	

(Continues)

**TABLE 2** (Continued)

Independent variables	Marginal effects <sup>a</sup>	p-value
Market concentration		<0.001
Concentrated (HHI ≥ 0.15)	(Ref)	
Unconcentrated (HHI < 0.15)	1.68	

Abbreviations: HHI, Herfindahl–Hirschman Index; IQR, interquartile range; NH, nursing home; RN, registered nurse.

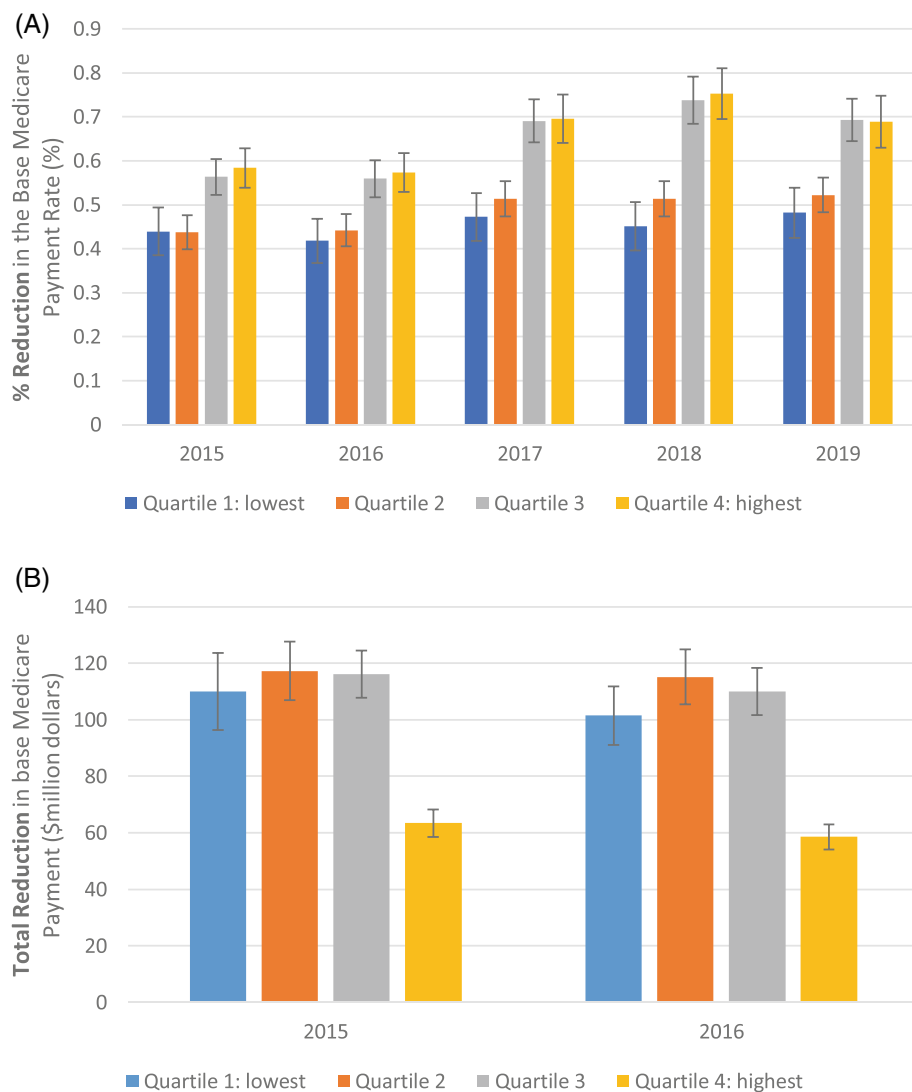
<sup>a</sup>Marginal effect: for discrete variables, marginal effects represented the discrete change in % hospital share of NH-originating hospitalizations relative to the reference group. For continuous variables that were standardized, marginal effects were the average change in % hospital share of NH-originating hospitalizations per standard deviation increase in the independent variable.

<sup>b</sup>Results of the joint test of the variable taking as a whole.

<sup>c</sup>For these continuous variables with quadratic terms, we calculated the average of the average marginal effects across the range of the value of the independent variable.

quality of care. We found that hospitals that had a higher share of NOHs tended to have characteristics associated with poorer clinical performance, for example, for profit ownership and lower nurse staffing levels.<sup>23,39–42</sup> Although the causal link between hospital ownership and quality of care remains controversial,<sup>43</sup> evidence for the effects of lower nurse staffing on quality appears to be more consistent.<sup>41,42</sup>

Findings from this study have important policy implications. Should the current HRRP policy be modified to avoid adversely penalizing hospitals that disproportionately care for frail older adults residing in NHs? If the share of NH residents also captures quality or system-level factors other than case mix, adjusting for admissions from NHs may weaken the incentives to hospitals to improve quality. Nevertheless, even if the higher penalties among high-NOH hospitals reflect, in part, deficiencies in quality and therefore do not meet criteria for risk adjustment, the increased penalties may pose tremendous challenges to these hospitals' ability to improve quality. This study suggests that these high-NOH hospitals may already face financial hardship by disproportionately serving low-income patients, operating at lower occupancy rates, and receiving lower base DRG payment from Medicare. Studies also suggest that NH residents exert increased workload on care providers (e.g., more face-to-face contacts, additional consulting time, etc.)<sup>44,45</sup> and incur higher costs,<sup>45,46</sup> which may not be adequately reimbursed under the current inpatient prospective payment system that does not account for frailty.<sup>47</sup> Therefore, hospitals serving a higher proportion of NOHs may be financially distressed and have fewer resources to invest in improving quality. The situation may be exacerbated by the increased readmission penalties. Future



**FIGURE 2** Adjusted readmission penalties in fiscal years 2015–2019 for each hospital quartile of the share of nursing home-originating hospitalizations, among hospitals with over 50 beds. (A) Percent reduction in base payment. (B) Aggregated reduction in base payment, million dollars. Source: Authors' analysis of CMS HRRP supplemental data files (2015–2019), Medicare Provider Analysis and Review files, Minimum Data Set, Provider of Services files, Medicare Impact File, Certification and Survey Provider Enhanced Reporting data, Area Health Resources files (2010–2013), hospital-specific DRG payment ratio for each DRG (2019), national average Medicare reimbursement rate for each DRG (2015 and 2016, the 2 years with information available). Note: Error bars indicated 95% confidence intervals of the margins. Results adjusted for hospital characteristics, market characteristics, state fixed effects. Methods are described in Supplement.

research is needed to discern the effect of patient case mix from the effect of clinical performance and other system-level factors. One strategy is to examine the effects of NOH on readmission risks after accounting for hospital share of NOHs (e.g., variation in readmissions by NOH status within high-NOH hospitals). Prior research utilizing similar analytical strategies suggests that both case-mix and “site-of-care” might influence readmission performance.<sup>4</sup>

Approximately 2500 hospitals will be penalized at a total amount of \$521 million reduction in Medicare reimbursement in FY2022.<sup>48</sup> Given the ongoing impact of readmission performance on hospitals' reimbursement, it is imperative that hospitals serving NH residents devise strategies to improve readmission performance focused on patients admitted from NHs. One strategy that hospitals may consider is to improve the care coordination with the NHs that they historically serve. This strategy may be particularly important for hospitals in localities with limited access to high-performing NHs<sup>49</sup> or when steering patients to high-performing NHs may not be feasible.

This study has several limitations. First, due to the small variation in NOHs over time, we were not able to conduct a longitudinal analysis which could have allowed us to gauge the causal impact of NOHs on readmission performance. However, we controlled for an extensive set of covariates predictive of hospital share of NOHs. Second, although we showed that hospital share of NOHs were relatively stable over time as indicated by the high correlation during 2010–2013, the correlation and the share of NOHs may change in subsequent years. Our analysis stratified hospitals into quartiles and estimated differences in adjusted readmission penalties by quartile; the proportion of hospitals switching between quartiles may be small. Any switching between quartiles and the subsequent measurement error in the explanatory variables may lead to biased estimates. Third, our estimates for hospital share of NOHs were based on FFS Medicare beneficiaries and thus may not be generalizable to other insured older adults such as those covered by Medicare Advantage, though the HRRP program

exclusively focused on FFS Medicare. Fourth, the relationship between hospital share of NOHs and readmission penalties may be overestimated, depending on the degree to which NOHs included HRRP target readmissions. Nevertheless, the readmission penalties were calculated based on all patients; given that only about 11% of patients were admitted from NHs the impact of double counting should be minimal and should not change the conclusions. In addition, double counting does not apply to the analysis for penalties beyond FY2015 where the data sources for NOHs and readmission penalties did not overlap.

## CONCLUSION

Hospitals varied considerably in their share of NOHs. Hospitals having a higher share of NOHs were disproportionately penalized for readmissions, even under the revised policy that adjusts for the share of dual-eligible admissions. Hospitals with higher NOHs were more likely to care for a higher proportion of disadvantaged populations suggesting that the current HRRP penalties might have devastating impact on these hospitals' financial viability and their ability to invest in quality. Hospitals may want to allocate resources to improve care coordination with NHs.

## AUTHOR CONTRIBUTIONS

Study concept and design (all authors), acquisition of subjects and/or data (Zhiqiu Ye, Helena Temkin-Greener, Orna Intrator), analysis and interpretation of data (all authors), preparation of the manuscript (all authors).

## CONFLICT OF INTEREST

Authors have no conflicts of interest to report.

## SPONSOR'S ROLE

None.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

**Table S1** Characteristics of hospital stays occurring in all 2868 HRRP participating hospitals with over 50 beds, stratified by nursing home-originating status.

**Table S2.** Aggregated base DRG payment for each hospital quartile of the share of NOH.

**Figure S1.** Distribution of hospital share of NOHs defined as admissions within **7-days** of discharge from a

NH, among hospitals with more than 50 beds, July 2010–June 2013.

**Table S3.** Correlation matrix of hospital share of NOHs in different performance periods during July 2010–June 2013, among hospitals with over 50 beds.

**Figure S2.** Adjusted readmission penalties in fiscal years 2015–2019 within each hospital quartile of the share of nursing home-originating hospitalizations, **controlling for the share of minority and dual-eligible admissions.**

**Tables S4–S8.** Specification of the GLM model (logit link) estimating the impact of hospital share of NOHs on readmission penalties in fiscal years 2015–2019 (results of each year in separate tables), with and without controlling for the share of minority and dual-eligible admissions.

**Figure S3.** Adjusted readmission penalties in fiscal years 2015–2019 within each hospital quartile of the share of nursing home-originating hospitalizations, **excluding hospitals that owned NHs**, with and without controlling for the share of minority and dual-eligible admissions ( $n = 2309$ ).

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