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RESEARCH ARTICLE

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Changes in coding of pneumonia and impact on the Hospital Readmission Reduction Program

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Abstract

Objective: To evaluate whether changes in diagnosis assignment explain reductions in 30-day readmission for patients with pneumonia following the Hospital Readmission Reduction Program (HRRP).

Data Sources: 100 percent MedPAR, 2008-2015.

Study Design: Retrospective cohort study of Medicare discharges in HRRP-eligible hospitals. Outcomes were 30-day readmission rates for pneumonia under a "narrow" definition (used for the HRRP until October 2015; n = 2 288 644) and a "broad" definition that included certain diagnoses of sepsis and aspiration pneumonia (used since October 2015; n = 3 618 215). We estimated changes in 30-day readmissions in the pre-HRRP period (January 2008-March 2010), the HRRP implementation period (April 2010-September 2012), and the HRRP penalty period (October 2012-June 2015).

Principal Findings: Under the narrow definition, adjusted annual readmission rates changed by +0.07 percentage points (pp) during the pre-HRRP period (95% CI: −0.03 pp, +0.18 pp), −1.07 pp during HRRP implementation (95% CI: −1.15 pp, −0.99 pp), and −0.09 pp during the penalty period (95% CI: −0.18 pp, −0.00 pp). Under the broad definition, 30-day readmissions changed by +0.21 pp during the pre-HRRP period (95% CI: +0.12 pp, +0.30 pp), −1.28 pp during HRRP implementation (95% CI: −1.35 pp, −1.21 pp), and −0.09 pp during the penalty period (95% CI: −0.16 pp, −0.02 pp).

Conclusions: Changes in the coding of inpatient pneumonia admissions do not explain readmission reduction following the HRRP.

KEYWORDS
coding, pneumonia, readmission rates

1 | INTRODUCTION

Created by the Affordable Care Act (ACA) in March 2010, the Medicare Hospital Readmission Reduction Program (HRRP) is the most financially salient value-based payment program for US hospitals. The program is expected to penalize hospitals more than $565 million in fiscal year 2019 as a result of excess risk-adjusted 30-day readmission rates for six common conditions or procedures.[1] Most evidence suggests that the HRRP has been successful in reducing risk-adjusted readmission rates for targeted diagnoses.[2-6]

Despite its apparent success, researchers have raised concerns about potential unintended consequences under the program.[2,7,8] One such concern relates to hospital coding practices. Changes in coded severity or diagnosis definitions have the potential to improve

hospitals' measured performance under the HRRP without reflecting improved quality.[9,10] Readmission rates for patients with pneumonia may have been particularly vulnerable to variations in provider coding practices since many pneumonia inpatients may reasonably be assigned principal diagnoses other than pneumonia.[11,12] Shifting high-risk patients to principal diagnoses of aspiration pneumonia and sepsis—diagnoses not included the HRRP's definition of pneumonia until a rule change in fiscal year 2015—could have improved hospitals' measured readmission performance under the HRRP.[12]

In this context, we performed a longitudinal analysis using national Medicare data to evaluate whether changes in diagnostic coding for pneumonia affected readmission reduction under the HRRP. We also examined the hospital characteristics associated with potentially advantageous coding.

2 | METHODS

2.1 | Data sources and study population

We used the Medicare Provider Analysis and Review (MedPAR) files for calendar years 2008 through 2015 to obtain detail for all inpatient hospital discharges for Medicare fee-for-service beneficiaries. We used International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and Centers for Medicare & Medicaid Services (CMS) criteria to identify three sets of discharges that are related to pneumonia.[12] The "narrow" definition includes discharges with a principal diagnosis of pneumonia present-on-admission (ICD-9-CM 480.X, 481, 482.XX, 483.X, 485, 486, 487.0, or 488.11). This definition, with only minor variations, was used between the establishment of the HRRP in April 2010 and September 2015. The "broad" definition includes discharges with a principal diagnosis of (a) pneumonia present-on-admission; (b) aspiration pneumonia present-on-admission (ICD-9-CM 507.0); or (c) sepsis present-on-admission (excluding severe sepsis), if accompanied by a secondary diagnosis of pneumonia or aspiration pneumonia (ICD-9-CM codes for sepsis: 038.x or 995.91). This definition has been used in the HRRP since October 2015. The "broad, not narrow" definition includes discharges with a principal diagnosis meeting the "broad" but not the "narrow" definition—discharges resulting from potentially advantageous coding practices for HRRP-eligible hospitals.

For each definition, we excluded discharges that were not subject to the HRRP per CMS guidelines.[11] This included beneficiaries who lacked Part A or Part B enrollment within 30 days of discharge (except if due to death), beneficiaries younger than 65, beneficiaries covered by a primary payer other than Medicare, and beneficiaries discharged against medical advice. We excluded potential index admissions after June 1, 2015, as to avoid changes associated with the retirement of ICD-9 and the implementation of ICD-10. We also excluded discharges from critical access hospitals and hospitals in Maryland.

Hospital characteristics were obtained from the 2008-2015 American Hospital Association Annual Surveys. Hospital profitability was obtained using Medicare cost reports for the relevant years.[13]

2.2 | Study outcome

The primary outcome was unplanned 30-day all-cause readmissions related to pneumonia. We calculated pneumonia readmission rates using each of the three pneumonia definitions described above.

2.3 | Statistical analysis

We calculated standard descriptive statistics for the index admissions, outcomes, and covariates, using each of the three pneumonia discharge definitions. We then modeled the likelihood of a 30-day readmission using multivariable generalized least-squares linear regression models with hospital random effects. We estimated separate models for each pneumonia cohort because the identification of index admissions and readmissions is contingent on the cohort definition. Consistent with other HRRP research,[3] we specified linear splines with knots occurring in April 2010 (corresponding with enactment of the HRRP) and October 2012 (corresponding with imposition of the first HRRP penalties) to capture changes in monthly readmission trends. Patient-level covariates included sex, age, race, and Elixhauser comorbidities.[14] We adjusted for seasonality using month of discharge. Hospital-level covariates included urban/rural location, teaching status, organizational structure, number of beds, region, share of Medicare and Medicaid inpatient days, and quintile of recent profitability. (Information on the profitability measure is provided in the Methods in Appendix S1.)[13]

All statistical analyses were conducted in *Stata*, version 15.0 (Stata Corp). Statistical tests were 2-sided, with $P < .05$ considered statistically significant.

3 | RESULTS

3.1 | Index admissions and patient characteristics

There were 2 288 644 HRRP-eligible index admissions under the narrow definition for pneumonia between January 2008 and June 2015 (Table 1). Seasonally adjusted index admissions under the narrow definition increased at an average monthly rate of 0.34 percent before April 2010 and an average monthly rate of 0.17 percent after April 2010 (data not shown). Index admissions for the broad definition totaled 3 618 215 between January 2008 and June 2015. Seasonally adjusted admissions under the broad definition increased at an average monthly rate of 1.47 percent before April 2010 and at an average rate of 0.43 percent monthly after April 2010. Broad-not-narrow index admissions totaled 1 383 005 over the study period. Seasonally adjusted broad-not-narrow index discharges increased at an average monthly rate of 6.12 percent before April 2010 and increased 0.90 percent monthly after April 2010.

Patients discharged with broad-not-narrow diagnoses tended to be older, were more likely to be male, and were less likely to be white relative to patients discharged with narrow diagnoses (Table 1). Prior to April 2010, patients discharged with broad-not-narrow diagnoses had fewer comorbidities; this pattern was reversed for the period following

TABLE 1 HRRP-eligible index inpatient admissions for pneumonia, by CMS specification, 2008-2015

	Narrow definition (n = 2 288 644)[a,b]		Broad definition (n = 3 618 215)[a,b]		Broad, not narrow (n = 1 383 005)[a,b]	
	Before HRRP (1/08-3/10)	After HRRP (4/10-6/15)	Before HRRP (1/08-3/10)	After HRRP (4/10-6/15)	Before HRRP (1/08-3/10)	After HRRP (4/10-6/15)
Qualifying admissions and readmissions						
Index admissions for period (per month)	755 155 (27 969)	1 533 489 (24 341)	1 057 042 (39 149)	2 561 173 (40 654)	315 855 (11 698)	1 067 150 (16 939)
Readmitted within 30 d (% of total)	132 565 (17.6%)	257 063 (16.8%)	194 641 (18.5%)	446 324 (17.4%)	66 430 (21.0%)	200 409 (18.8%)
Principal discharge diagnosis						
Pneumonia (excl. aspiration, % of total)	755 155 (100.0%)	1 533 489 (100.0%)	749 851 (70.9%)	1 517 572 (59.3%)	–	–
Aspiration pneumonia (% of total)	—	—	168 664 (16.0%)	333 613 (13.0%)	174 177 (55.1%)	343 733 (32.2%)
Sepsis (% of total)	—	—	138 527 (13.1%)	709 988 (27.7%)	141 678 (44.9%)	723 417 (67.8%)
Demographics and morbidity						
Male (% of total)	335 506 (44.4%)	685 236 (44.7%)	485 636 (45.9%)	1 194 878 (46.7%)	157 739 (49.9%)	530 436 (49.7%)
Mean age (SD)	81.0 (8.3)	81.1 (8.5)	81.3 (8.3)	81.3 (8.5)	82.1 (8.3)	81.5 (8.6)
White (% of total)	663 150 (87.8%)	1 340 424 (87.4%)	916 330 (86.7%)	2 203 206 (86.0%)	264 848 (83.9%)	896 062 (84.0%)
Mean Elixhauser comorbidities (SD)	2.9 (1.3)	3.9 (1.9)	2.8 (1.3)	4.0 (1.9)	2.5 (1.2)	4.2 (2.0)
Hospital of index admission						
Urban (% of total)	713 622 (94.5%)	1 459 527 (95.2%)	1 006 540 (95.2%)	2 460 517 (96.1%)	306 280 (97.0%)	1 039 033 (97.4%)
Teaching hospital (% of total)	92 979 (12.3%)	180 518 (11.8%)	135 253 (12.8%)	328 420 (12.8%)	44 186 (14.0%)	153 199 (14.4%)
Structure						
For-profit (% of total)	106 903 (14.2%)	245 290 (16.0%)	149 645 (14.2%)	400 962 (15.7%)	44 823 (14.2%)	162 053 (15.2%)
Not-for-profit (% of total)	549 990 (72.8%)	1 104 704 (72.0%)	776 504 (73.5%)	1 869 378 (73.0%)	236 736 (75.0%)	793 298 (74.3%)
Other (% of total)	98 262 (13.0%)	183 495 (12.0%)	130 893 (12.4%)	290 833 (11.4%)	34 296 (10.9%)	111 799 (10.5%)
Size						
200 beds or fewer (% of total)	292 748 (38.8%)	581 928 (37.9%)	388 154 (36.7%)	909 286 (35.5%)	100 290 (31.8%)	340 592 (31.9%)
200-349 beds (% of total)	219 530 (29.1%)	440 659 (28.7%)	312 799 (29.6%)	746 227 (29.1%)	97 516 (30.9%)	317 543 (29.8%)
350-499 beds (% of total)	115 900 (15.3%)	240 287 (15.7%)	171 064 (16.2%)	418 825 (16.4%)	57 508 (18.2%)	185 095 (17.3%)
500 or more beds (% of total)	126 977 (16.8%)	270 615 (17.6%)	185 025 (17.5%)	486 835 (19.0%)	60 541 (19.2%)	223 920 (21.0%)
Region						
Midwest (% of total)	189 194 (25.1%)	377 519 (24.6%)	260 685 (24.7%)	615 472 (24.0%)	74 862 (23.7%)	247 470 (23.2%)
Northeast (% of total)	147 292 (19.5%)	291 141 (19.0%)	209 602 (19.8%)	500 773 (19.6%)	65 335 (20.7%)	217 228 (20.4%)

(Continues)

TABLE 1 (Continued)

	Narrow definition (n = 2 288 644)[a,b]		Broad definition (n = 3 618 215)[a,b]		Broad, not narrow (n = 1 383 005)[a,b]	
	Before HRRP (1/08-3/10)	After HRRP (4/10-6/15)	Before HRRP (1/08-3/10)	After HRRP (4/10-6/15)	Before HRRP (1/08-3/10)	After HRRP (4/10-6/15)
South (% of total)	311 688 (41.3%)	648 223 (42.3%)	428 551 (40.5%)	1 034 951 (40.4%)	122 404 (38.8%)	402 702 (37.7%)
West (% of total)	106 981 (14.2%)	216 606 (14.1%)	158 204 (15.0%)	409 977 (16.0%)	53 254 (16.9%)	199 750 (18.7%)
Profitability of admitting hospital[c]						
First quintile (% of total)	162 036 (21.5%)	304 640 (19.9%)	227 240 (21.5%)	497 160 (19.4%)	68 443 (21.7%)	200 358 (18.8%)
Second quintile (% of total)	163 273 (21.6%)	321 257 (20.9%)	218 660 (20.7%)	506 795 (19.8%)	58 282 (18.5%)	193 271 (18.1%)
Third quintile (% of total)	149 906 (19.9%)	310 686 (20.3%)	208 693 (19.7%)	516 569 (20.2%)	61 413 (19.4%)	213 898 (20.0%)
Fourth quintile (% of total)	143 181 (19.0%)	303 739 (19.8%)	202 773 (19.2%)	519 361 (20.3%)	62 189 (19.7%)	223 664 (21.0%)
Fifth quintile (% of total)	136 759 (18.1%)	293 167 (19.1%)	199 676 (18.9%)	521 288 (20.4%)	65 528 (20.7%)	235 959 (22.1%)
Payer mix (inpatient days)						
Medicare days, % of total (SD)	51.6% (0.122)	52.2% (0.120)	51.5% (0.120)	51.9% (0.118)	51.2% (0.115)	51.4% (0.115)
Medicaid days, % of total (SD)	17.4% (0.106)	18.5% (0.106)	17.5% (0.105)	18.8% (0.106)	17.6% (0.103)	19.2% (0.106)

[a]Sum of "narrow" cases and "broad, not narrow" cases does not equal number of "broad" cases because count of qualifying index admissions depends on which admissions are considered 30-day readmissions. Per CMS rules, admissions categorized as 30-day readmissions cannot be index admissions.
[b]All differences in patient characteristics between the pre- and post-HRRP periods for each cohort are significant at $P < .001$ with two exceptions: (a) the share of patients admitted to a teaching hospital pre- and post-HRRP in the broad cohort is not significant, and (b) the share of male patients pre- and post-HRRP in the broad-not-narrow cohort is significant at $P < .05$.
[c]Average of admitting hospital's 5 y of net income prior to year of index admission. Quintiles were calculated based on share of index admissions (broad definition) for specific 5-y period, per CMS cost reports. See Appendix S1.

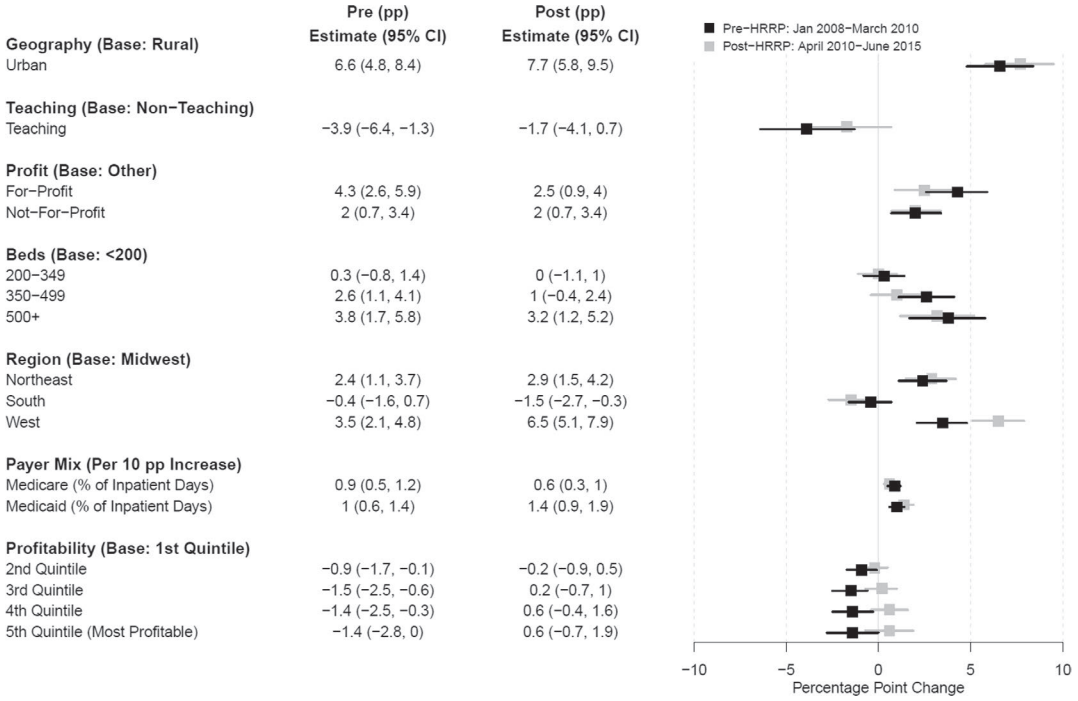
implementation of the HRRP. Patients assigned broad-not-narrow diagnoses were more likely to be discharged from urban hospitals, teaching hospitals, nonprofit hospitals, larger hospitals, and more profitable hospitals. These patients were generally more likely to be treated in the northeast or west relative to the midwest or south (Table 1).

Before April 2010, 55.1 percent of broad-not-narrow discharges were assigned a principal discharge diagnosis of aspiration pneumonia; 44.9 percent were assigned a principal discharge diagnosis of sepsis (Table 1). After April 2010, 67.8 percent of broad-not-narrow discharges received a primary discharge diagnosis of sepsis rather than aspiration pneumonia. Additional details on cohort characteristics by primary discharge diagnosis are provided in Appendix S1.

3.2 | Association between hospital characteristics and assignment of broad-not-narrow diagnoses

Before implementation of the HRRP, assignment of broad-not-narrow diagnosis codes was significantly more common among urban hospitals relative to rural hospitals, among nonteaching hospitals relative to teaching hospitals, among for-profit and not-for-profit hospitals relative to other hospitals, among larger hospitals relative to smaller hospitals, among hospitals in the northeast and west relative to the midwest and south, and among hospitals with larger shares of Medicare and Medicaid discharges (Figure 1). Medicare inpatient days were associated with an increase in broad-not-narrow diagnosis assignment of +0.90 percentage points (pp) per 10 pp increase in share of days (95% CI: 0.50, 1.20). Hospitals in the lowest quintile of profitability were significantly more likely to assign broad-not-narrow diagnoses, but the magnitude of this effect was never >1.5 pp.

Estimates for tendency to assign broad-not-narrow diagnoses did not change significantly following the enactment of the HRRP, with one exception. Hospitals in the west became significantly more likely to assign broad-not-narrow diagnoses post-HRRP (Figure 1) (*P*-values not adjusted for multiple comparisons). While hospitals with higher levels of profitability also became more likely to assign broad-not-narrow diagnoses, these effects did not reach statistical significance.



[a] All estimates adjusted for month of discharge as well as the patient-level characteristics shown in Table 1. Error bars indicate 95% confidence intervals.

FIGURE 1 Adjusted likelihood of receiving broad-not-narrow diagnosis by hospital characteristic[a]

3.3 | Readmissions

Adjusted readmission rates were 18.80 percent (95% CI: 18.65, 18.96 percent) in January 2008 under the narrow definition of pneumonia, 19.83 percent under the broad definition (95% CI: 19.66, 19.99 percent), and 22.94 under the broad-not-narrow definitions (95% CI: 22.68, 23.21 percent) (Table 2, Figure 2). For the narrow definition, 30-day readmissions changed at an annual rate of +0.07 pp before the HRRP (95% CI: −0.03 pp, +0.18 pp), −1.07 pp during the HRRP implementation period (95% CI: −1.15 pp, −0.99 pp), and −0.09 pp during the HRRP penalty period (95% CI: −0.18 pp, −0.00 pp). Under the broad definition, readmissions changed by annual rates of +0.21 pp during the pre-HRRP period (95% CI: +0.12 pp, +0.30 pp), −1.28 pp during implementation (95% CI: −1.35 pp, −1.21 pp), and −0.09 pp in the penalty period (95% CI: −0.16 pp, −0.02 pp). Broad-not-narrow readmissions changed at annual rates of −0.37 pp (95% CI: −0.55 pp, −0.18 pp), −1.64 pp (95% CI: −1.75 pp, −1.52 pp), and −0.25 pp (95% CI: −0.36 pp, −0.15 pp) during the three periods.

Readmissions declined faster between the pre-HRRP period and the HRRP implementation period when measured under the broad definition than when measured under the narrow definition: The annual rate of pneumonia readmissions changed by −1.14 pp (95% CI: −1.31 pp, −0.98 pp) under the narrow definition and −1.49 pp (95% CI: −1.63 pp, −1.35 pp) under the broad definition. The change in readmission rates between the penalty period and the implementation period was not significantly different across the broad (+1.19 pp [95% CI: +1.07 pp, +1.31 pp]) and narrow (+0.98 pp [95% CI: +0.83 pp, +1.13 pp]) definitions. However, changes in readmission rates differed significantly between these two periods under the broad-not-narrow definition (+1.39 pp [95% CI: +1.19 pp, +1.58 pp]) compared to the narrow definition.

When analyzed with only two periods—January 2008-March 2010 (pre-HRRP) and after April 2010-June 2015 (post-HRRP)—changes in readmission rates between the broad definition and narrow definitions were not significantly different (Appendix S1: Table S4).

4 | DISCUSSION

Drawing on 7 years of Medicare inpatient claims to examine the relationship between diagnosis coding for pneumonia and readmission rates, we report three key findings. First, use of broad-not-narrow diagnosis codes was increasing prior to the March 2010 creation of the HRRP; advantageous coding practices did not accelerate in conjunction with the program's establishment. In fact, use of these diagnosis codes grew more slowly after April 2010 than before. Second, the use of broad-not-narrow diagnosis codes did not significantly accelerate reductions in 30-day readmissions for pneumonia in either of the post-HRRP periods. Third, hospital characteristics explain relatively little variation in tendency to assign a broad-not-narrow diagnosis code.

4.1 | Coding practices

Given hospitals' potential to improve performance on the pneumonia readmission measure, it is perhaps surprising that coding

TABLE 2 Adjusted trends in pneumonia readmission rates before and after HRRP creation, by pneumonia definition[a]

	Narrow definition	Broad definition	Broad, not narrow
Baseline readmission rate[b]—percent, (95% CI)	18.8 (18.65, 18.96)	19.83 (19.66, 19.99)	22.94 (22.68, 23.21)
Pre-HRRP annual rate of change[c,d]—percentage point, (95% CI)	0.07 (−0.03, 0.18)	0.21*** (0.12, 0.30)	−0.37*** (−0.55, −0.18)
Annual rate of change, implementation[d,e]—percentage point, (95% CI)	−1.07*** (−1.15, −0.99)	−1.28*** (−1.35, −1.21)	−1.64*** (−1.75, −1.52)
Annual rate of change, penalty[d,f]—percentage point, (95% CI)	−0.09* (−0.18, −0.00)	−0.09** (−0.16, −0.02)	−0.25*** (−0.36, −0.15)
Difference between implementation and pre-HRRP—percentage point, (95% CI)	−1.14*** (−1.31, −0.98)	−1.49*** (−1.63, −1.35)	−1.27*** (−1.54, −1.00)
Difference between penalty and implementation—percentage point, (95% CI)	0.98*** (0.83, 1.13)	1.19*** (1.07, 1.31)	1.39*** (1.19, 1.58)

[a]All figures adjusted for month of discharge and the patient- and hospital-level characteristics shown in Table 1.
[b]January 2008.
[c]January 2008 through March 2010.
[d]Rates of change were calculated from linear spline models knots in the splines in April 2010 (corresponding with enactment of the HRRP) and October 2012 (corresponding with imposition of the first HRRP penalties) to capture changes in monthly readmission trends.
[e]April 2010 through September 2012.
[f]October 2012 through June 2015.
*$P < .05$;
**$P < .01$;
***$P < .001$.

of aspiration pneumonia and sepsis did not accelerate following HRRP implementation. Sjoding et al[11] found that hospitals could significantly improve performance on the narrow HRRP pneumonia measure by selectively changing the discharge diagnosis for certain pneumonia patients with organ failure to discharge diagnoses of sepsis or respiratory failure. In simulations, two-thirds of hospitals with above-average readmissions perfectly pursuing this coding optimization strategy improved their apparent performance—with potentially meaningful implications for HRRP penalties.

Changes in the coding of inpatient pneumonia and related conditions prior to the launch of HRRP might explain the lack of a clear and consistent effect of coding changes on readmissions. Lindenauer et al[15] reported that inpatient coding of sepsis and respiratory failure increased at the apparent expense of coding of pneumonia between 2003 and 2009. There are many possible explanations for this trend including higher payment for sepsis- and aspiration pneumonia-linked diagnosis-related groups (DRGs) relative to pneumonia-linked DRGs,[16] and the public reporting of 30-day readmission rates by CMS for pneumonia in July 2009—nine months prior to creation of the HRRP. For these reasons, dynamics favoring the shift of coding practices toward aspiration pneumonia and sepsis may have already played out to a large extent prior to the HRRP.

4.2 | Readmission rates

Recognizing the potential of changes in coding practices to undermine the intent of the HRRP, CMS broadened the definition of HRRP-eligible pneumonia discharges in October 2015 to include hospitalizations with primary discharge diagnoses of aspiration pneumonia or sepsis when coupled with pneumonia.[17] We found that use of broad-not-narrow coding would have exerted a limited effect on overall readmission rates had these discharges always been included in the HRRP. When analyzed with three periods, findings suggest that the program-wide pneumonia readmission trend would have improved significantly faster in the HRRP implementation period (relative to the pre-HRRP period) while deteriorating insignificantly faster in the HRRP penalty period (relative to the HRRP implementation period). Yet these effects are relatively small in magnitude and do not affect the overall conclusion that readmission rates declined across pneumonia-linked diagnoses.

Two unexpected findings relate to trends in 30-day readmission rates specific to the broad-not-narrow cohort. First, we found that 30-day readmission rates were lower in the post-HRRP period relative to the pre-HRRP period for patients discharged with broad-not-narrow diagnosis (Table 1). Second, compared to patients discharged with pneumonia (ie, the narrow cohort), we found that the readmission rate declined faster for patients with

broad-not-narrow diagnoses—particularly during the pre-HRRP period and the implementation period (Table 2). These findings may be related to shifts in the composition of the broad-not-narrow cohort over our study period. Whereas the broad-not-narrow population was comprised mostly of patients with aspiration pneumonia prior to April 2010, two-thirds of broad-not-narrow patients in this group had a principal diagnosis of sepsis after April 2010 (see Table 1)—consistent with the longer-term trends reported by Lindenauer et al[15] toward greater coding of sepsis. On average, patients with sepsis tended to be 2.9 younger and have a 0.29 percentage point lower readmission rate relative to patients with aspiration pneumonia (Appendix S1: Tables S1 and S2). Together, these observations suggest that changes in the composition of the broad-not-narrow cohort between 2008 and 2015 may account for some of the observed decline in readmissions in this cohort.

The spillover of readmission avoidance efforts to conditions not explicitly targeted in policy is also consistent with our finding of reduced readmissions for patients with broad-not-narrow diagnoses. That is, providers may have focused any readmission avoidance efforts at the level of the general condition (eg, patients with pneumonia-related condition) rather than the specific ICD-9 discharge diagnoses specified in policy. If true, this finding would align with the HRRP literature suggesting the program has been associated with reductions in readmissions for medical conditions not explicitly targeted more generally.[3,4,18]

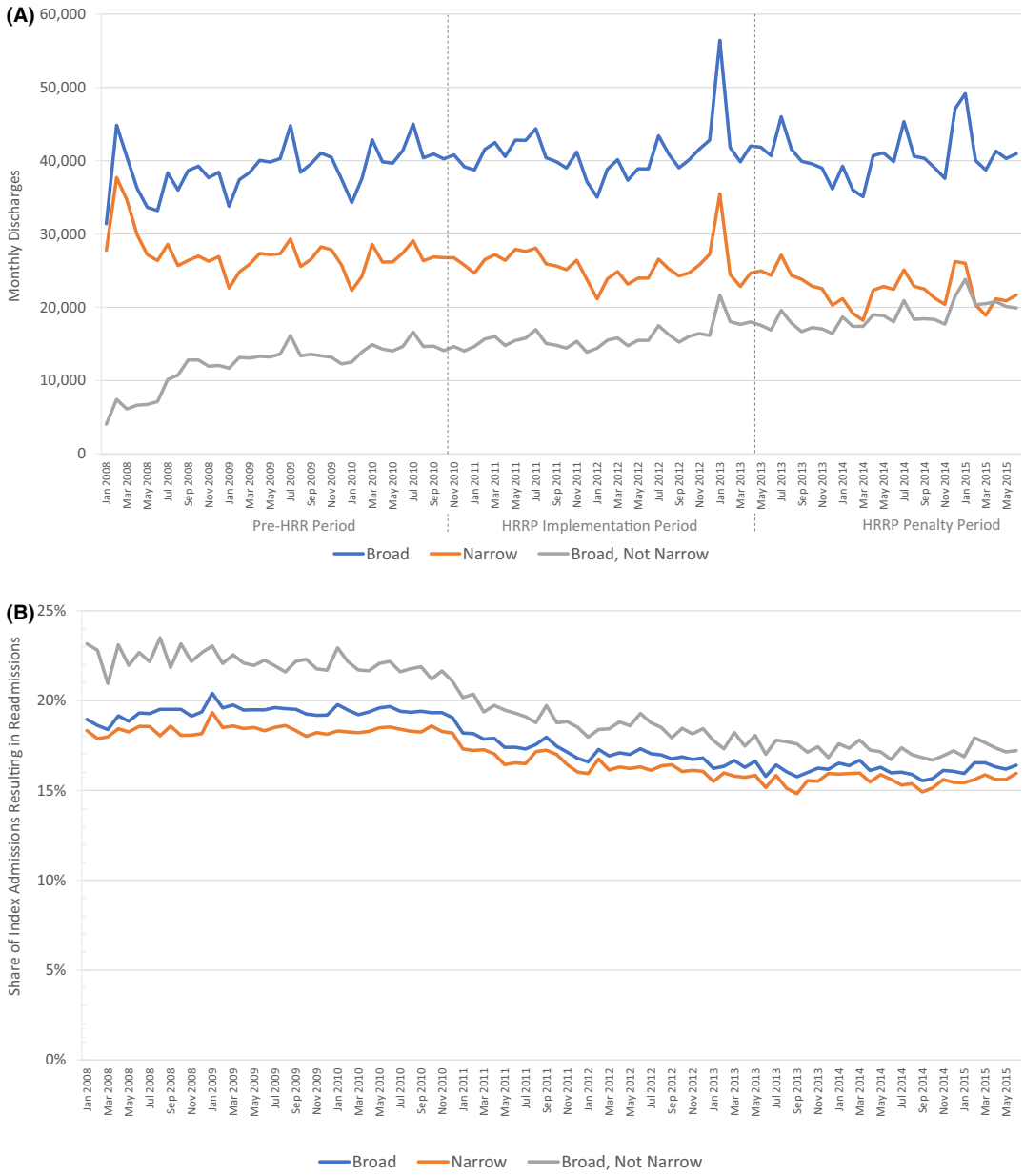


FIGURE 2 A, Index discharges for pneumonia, by definition. Adjusted for season. B, 30-day readmissions for pneumonia, by definition. Adjusted for season, hospital characteristics, and patient characteristics [Color figure can be viewed at wileyonlinelibrary.com]

4.3 | Hospital characteristics

In general, hospital characteristics were only modestly associated with use of broad-not-narrow diagnoses. The tendency to assign broad-not-narrow diagnoses changed little from the pre-HRRP to the post-HRRP period. In the post-HRRP period, the most profitable hospitals—perhaps those most able to devote resources to coding optimization—were somewhat more likely to use advantageous coding practices relative to the least profitable hospitals. While our results were not significant, the pattern observed suggests that future work on the distributional impacts of value-based purchasing strategies should include measures of hospital profitability or wealth, not just payer mix and case mix.

4.4 | Limitations

Several limitations apply to our analyses. First, our study lacked a control group to gauge the impact of the HRRP itself on pneumonia readmissions. Despite the absence of a consistent, accelerated trend (Table 2, Figure 2), we cannot conclude that the creation of the HRRP had no effect on 30-day readmissions for pneumonia as progress in reducing readmissions might have slowed (or been reversed) but for the program's creation. Yet our finding of modest reductions in readmissions following the HRRP, including a "leveling-off" of progress during the penalty period,[3] is consistent with other research.

Second, while we found that nationwide changes around coding of pneumonia do not explain changes in readmissions under the HRRP, this does not extend to individual hospitals. Individual hospitals may have been meaningfully advantaged or disadvantaged through use of advantageous broad-not-narrow diagnosis codes.

Third, we are unable to explain the forces driving diagnosis decisions. As discussed above, it is possible that financial incentives played a meaningful role. However, it is also possible that variations in diagnosis decisions have corresponded to actual differences in patient acuity. The changing mix of diagnosis codes over the course of our study could also be due to changes in the quality of ambulatory care. For instance, improved outpatient care might have averted index hospitalizations for less acute cases of pneumonia. Uneven adoption of new coding practices consistent with the introduction of the Medicare Severity Diagnosis Related Group (MS-DRG) system in October 2007 may have played a role in the observed changes.[19] We lacked information on physiologic variables, such as laboratory results, that could provide more robust indications of acuity.

Fourth, our methodology did not replicate the HRRP methodology with complete precision. For example, we did not use each beneficiary's historical claims experience for purposes of risk adjustment. However, we did use inpatient discharge diagnoses for purposes of risk adjustment. These deviations are common in the literature on HRRP, and it is unlikely these discrepancies meaningfully biased our results in a particular direction.

Fifth, we did not make explicit allowance for changes in the intensity of comorbidity coding practices over time. As shown in Table 1—and documented in two recent studies[9,10]—the reporting of comorbidities in conjunction with HRRP-eligible diagnoses increased over the period of our study. This trend is likely related to the introduction of a new standard for the electronic submission of hospital claims between 2010 and 2012.[9,10]

4.5 | Implications for policy

Our findings suggest that hospitals' classification of pneumonia admissions have not been a clear driver of readmission reduction under the HRRP. This is encouraging as it suggests that strategic coding behavior from hospitals has not undermined the integrity of the program. At the same time, our findings should not be interpreted as suggesting that the CMS's move to broaden the pneumonia measure under the HRRP in October 2015 was unnecessary. Broader measures may better align with the underlying spirit and intent of the program. The HRRP was intended to reduce preventable readmissions—an outcome that matters for patients and taxpayers alike. However, these incentives were absent for hundreds of thousands of discharges prior to October 2015.

Broader measures can also expand the pool of hospitals that meet the minimum volume for participation. Analyses prepared for CMS indicated that the specification could change the readmission outlier status for about 8 percent of hospitals (page 50 of Lindenauer et al),[11] in large part due to the inclusion of hospitals newly meeting the minimum volume threshold. In part for these reasons, the Medicare Payment Advisory Commission has recommended replacing condition-specific readmission measures with an all-cause measure of readmissions.[20,21]

Administrative data are subject to a range of "nuances and vagaries" that complicate the development of performance measures that are valid, reliable, and fair.[22] Policy makers should continue to review and revise performance measures in the HRRP and other value-based payment programs to align measurement with programmatic goals.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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