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Association of the Hospital Readmissions Reduction Program With Mortality Among Medicare Beneficiaries Hospitalized for Heart Failure, Acute Myocardial Infarction, and Pneumonia

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IMPORTANCE The Hospital Readmissions Reduction Program (HRRP) has been associated with a reduction in readmission rates for heart failure (HF), acute myocardial infarction (AMI), and pneumonia. It is unclear whether the HRRP has been associated with change in patient mortality.

OBJECTIVE To determine whether the HRRP was associated with a change in patient mortality.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study of hospitalizations for HF, AMI, and pneumonia among Medicare fee-for-service beneficiaries aged at least 65 years across 4 periods from April 1, 2005, to March 31, 2015. Period 1 and period 2 occurred before the HRRP to establish baseline trends (April 2005-September 2007 and October 2007-March 2010). Period 3 and period 4 were after HRRP announcement (April 2010 to September 2012) and HRRP implementation (October 2012 to March 2015).

EXPOSURES Announcement and implementation of the HRRP.

MAIN OUTCOMES AND MEASURES Inverse probability–weighted mortality within 30 days of discharge following hospitalization for HF, AMI, and pneumonia, and stratified by whether there was an associated readmission. An additional end point was mortality within 45 days of initial hospital admission for target conditions.

RESULTS The study cohort included 8.3 million hospitalizations for HF, AMI, and pneumonia, among which 7.9 million (mean age, 79.6 [8.7] years; 53.4% women) were alive at discharge. There were 3.2 million hospitalizations for HF, 1.8 million for AMI, and 3.0 million for pneumonia. There were 270 517 deaths within 30 days of discharge for HF, 128 088 for AMI, and 246 154 for pneumonia. Among patients with HF, 30-day postdischarge mortality increased before the announcement of the HRRP (0.27% increase from period 1 to period 2). Compared with this baseline trend, HRRP announcement (0.49% increase from period 2 to period 3; difference in change, 0.22%, $P = .01$) and implementation (0.52% increase from period 3 to period 4; difference in change, 0.25%, $P = .001$) were significantly associated with an increase in postdischarge mortality. Among patients with AMI, HRRP announcement was associated with a decline in postdischarge mortality (0.18% pre-HRRP increase vs 0.08% post-HRRP announcement decrease; difference in change, −0.26%; $P = .01$) and did not significantly change after HRRP implementation. Among patients with pneumonia, postdischarge mortality was stable before HRRP (0.04% increase from period 1 to period 2), but significantly increased after HRRP announcement (0.26% post-HRRP announcement increase; difference in change, 0.22%, $P = .01$) and implementation (0.44% post-HPPR implementation increase; difference in change, 0.40%, $P < .001$). The overall increase in mortality among patients with HF and pneumonia was mainly related to outcomes among patients who were not readmitted but died within 30 days of discharge. For all 3 conditions, HRRP implementation was not significantly associated with an increase in mortality within 45 days of admission, relative to pre-HRRP trends.

CONCLUSIONS AND RELEVANCE Among Medicare beneficiaries, the HRRP was significantly associated with an increase in 30-day postdischarge mortality after hospitalization for HF and pneumonia, but not for AMI. Given the study design and the lack of significant association of the HRRP with mortality within 45 days of admission, further research is needed to understand whether the increase in 30-day postdischarge mortality is a result of the policy.

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Editorial page 2539

Supplemental content

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The Hospital Readmissions Reduction Program (HRRP) was established under the Affordable Care Act (ACA) in 2010 and required that the Centers for Medicare & Medicaid Services (CMS) impose financial penalties on hospitals with higher-than-expected 30-day readmission rates for patients with heart failure, acute myocardial infarction, and pneumonia, beginning in 2012.[1] After the announcement of the HRRP, readmission rates among Medicare beneficiaries declined for target conditions nationwide.[2,3] Recently, however, policy makers and physicians have raised concern that the HRRP may have also had unintended consequences that adversely affected patient care, potentially leading to increased mortality.[4,5] For instance, the financial penalties imposed by the HRRP may have inadvertently pushed some physicians to avoid indicated readmissions, potentially diverted hospital resources and efforts away from other quality improvement initiatives, or worsened quality of care at resource-poor hospitals that are often penalized by the program. However, it is also possible that the same mechanisms by which some hospitals have reduced readmissions, such as improved coordination and transitions of care, resulted in reductions in mortality.

Understanding whether the HRRP has been associated with changes in mortality at the patient level is important as policy makers evaluate this program, particularly given the ongoing expansion of the HRRP to include other conditions[6] and the almost $2 billion in financial penalties that have been imposed on hospitals since 2012.[7] This study aims to answer 3 questions. First, compared with past trends, was the announcement or implementation of the HRRP associated with a change in mortality within 30 days of discharge following hospitalization for heart failure, acute myocardial infarction, or pneumonia? Second, was the HRRP associated with a change in the distribution of patients who experienced death and no readmission, readmission and no death, readmission and death, or no death and no readmission during the 30 days after discharge? Third, was the HRRP associated with a change in mortality within 45 days of hospital admission for target conditions?

Key Points

Question Was the announcement and implementation of the Hospital Readmissions Reduction Program (HRRP) associated with an increase in patient-level mortality?

Findings In this retrospective cohort study that included approximately 8 million Medicare beneficiary fee-for-service hospitalizations from 2005 to 2015, implementation of the HRRP was associated with a significant increase in trends in 30-day postdischarge mortality among beneficiaries hospitalized for heart failure and pneumonia, but not for acute myocardial infarction.

Meaning There was a statistically significant association with implementation of the HRRP and increased post-discharge mortality for patients hospitalized for heart failure and pneumonia, but whether this finding is a result of the policy requires further research.

Methods

Institutional review board approval, including waiver of the requirement of participant informed consent because the data were deidentified, was provided by the Beth Israel Deaconess Medical Center.

Study Cohort

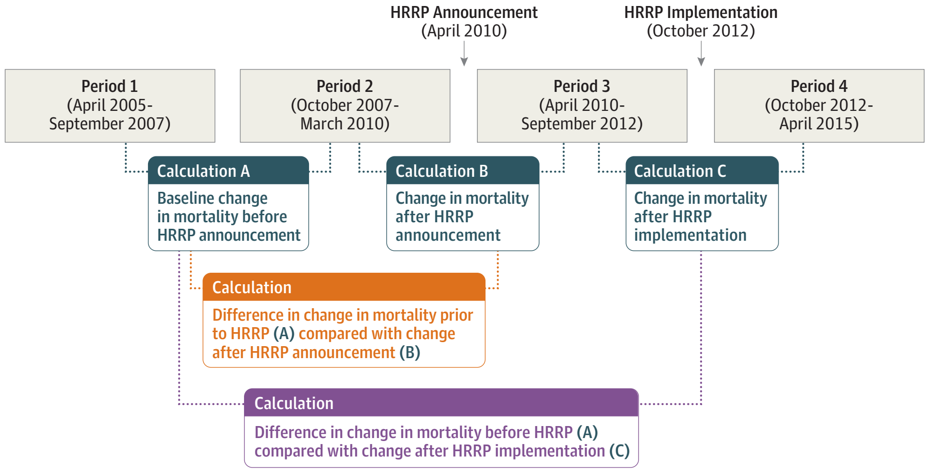
We used Medicare Provider Analysis and Review files to identify hospital admissions and discharges at short-term acute care hospitals from April 1, 2005, through March 31, 2015, with a principal discharge diagnosis of heart failure, acute myocardial infarction, or pneumonia. Study cohorts were defined using *International Classification of Diseases, Ninth Revision, Clinical Modification* codes used in the publicly reported CMS readmission and mortality measures.[8-10] We included Medicare beneficiaries aged 65 years or older in the analysis. We excluded patients who were discharged against medical advice, were not enrolled in Medicare fee-for-service for at least 30 days after discharge (absent death), or were enrolled in Medicare fee-for-service for less than 1 year before hospitalization. Transfers to other hospitals were linked to a single index hospitalization. To examine 30-day postdischarge outcomes, we also excluded patients who died during hospitalization. Comorbidities were defined using CMS hierarchical condition categories based on Medicare claims up to 1 year before hospitalization.[11] Specifically, we used covariates in the CMS risk-adjustment models for heart failure, acute myocardial infarction, and pneumonia,[12-14] as has been done in previous studies.[2,15] The race/ethnicity of all patients was identified based on claims files and was designated into the following fixed categories: white, black, or other. Race/ethnicity was included as a covariate in the analysis because it is associated with mortality for target conditions.[16]

Study Periods

We identified 4 nonoverlapping study periods of equal duration for index hospitalization. We chose to evaluate differences in outcomes between time periods, rather than annual trends, for 2 reasons. First, we were interested in changes in outcomes among time periods defined by their relationship to the announcement and implementation of the HRRP, rather than within-period trends. Second, this strategy avoids assumptions on how the HRRP imposes its effect on different patient groups (eg, assumptions on main effects and interaction terms) and of a linear relationship between outcomes and time and continuous confounders in a conventional logistic or multinominal regression model.

We identified 2 study periods before the HRRP was established to examine baseline trends in outcomes. The first study period included hospitalizations from April 2005 to September 2007 (period 1) and the second included hospitalizations from October 2007 to March 2010 (period 2). Two periods after the HRRP was established were also included: 1 following the initial announcement of HRRP with passage of the ACA from April 2010 through September 2012 (period 3) and the other between October 2012 and March 2015 (period 4), which

Figure 1. Study Periods and Analytic Approach in a Study of the Association Between the Hospital Readmissions Reduction Program (HRRP) and Mortality



is when the HRRP was implemented and hospitals were subjected to financial penalties. For patients with multiple hospitalizations within a time period, 1 index hospitalization was randomly selected for each condition.

Outcomes

Patient mortality within 30 days of discharge after a hospitalization (postdischarge mortality) for heart failure, acute myocardial infarction, and pneumonia was evaluated, which has been done in previous hospital-level analyses.[17-19] The following 30-day postdischarge outcome subgroups were also examined: (1) death and no readmission, (2) readmission and death, (3) readmission and no death, and (4) no readmission and no death. These subgroup outcomes were examined to try to provide mechanistic insights on the relationship between readmission and mortality. To fully assess trends in mortality related to a complete clinical episode, 45-day patient mortality rates following admission (postadmission mortality) were also evaluated, because efforts to reduce readmissions could potentially encompass care during hospitalization and might influence discharge timing and location of death. This measure included varying hospital lengths of stay and captured both in-hospital and 30-day postdischarge deaths for the majority of the cohort.

Statistical Analysis

To account for a potential imbalance in case mix between study periods, a propensity score approach (ie, the probability of being in a specific period given the demographics and comorbidities of the patient and calendar month of hospitalization) was used to standardize populations among periods. Patient demographics, comorbidities, and seasonal indicators (calendar month) from period 4 were used as a reference to reweight observed outcomes in all other study periods. Logistic regression models were fit on data from periods 1 and 4 to obtain a propensity score for period 1. The propensity score was then used to weight the outcomes in period 1, generating event rates through inverse probability weighting (IPW) that would have been observed if period 1 had the same case mix as period 4. Similarly, separate logistic regression models were fit to data from periods 2 and 4 and periods 3 and 4 to provide IPW-adjusted event rates in periods 2 and 3, respectively. This approach allowed the calculated distribution of each outcome in each of the 4 periods to be based on the same case mix (ie, the case mix from period 4).[20] Because the primary aim was to understand the association of the HRRP with mortality at the individual level, we did not examine hospital-level effects in the analysis.

To establish the change in rates of outcomes after the announcement of the HRRP, the change in event rates between periods 2 and 3 was calculated. Similarly, the change in rates of outcomes between periods 3 and 4 was also calculated to examine the change in outcomes between the announcement and the implementation of the HRRP (**Figure 1**).

To isolate the association between the HRRP and the outcomes, we sought to remove secular trends for each outcome. To do so, the change in outcomes between periods 1 and 2 was computed to establish a baseline trend in outcomes before the announcement and implementation of the HRRP. This difference was then subtracted from the change in outcomes after the announcement of the HRRP (between periods 2 and 3) to account for trends that were unrelated to the HRRP. Similarly, the baseline difference was also subtracted from the change in outcomes after the implementation of the HRRP, between periods 3 and 4.

Additional Analyses

Several sensitivity analyses were performed. First, patients enrolled in hospice were excluded because greater use of hospice care at the end of life might shift deaths that previously occurred within a hospital to the postdischarge setting over time.[21,22] Second, because 1 hospitalization was randomly selected for patients that experienced multiple hospitalizations in a given study period, the main analysis was repeated using the first hospitalization for each patient in each study period as well as all hospitalizations for each patient. Third, the entire analysis for postdischarge mortality was repeated using outcome regression within each study period to generate predicted outcomes for the case-mix in period 4, which were then directly compared across periods to ensure the results were not sensitive to the analytic approach used.

More details on the methodologic approach are provided in the Supplement. Significance testing was performed using z tests, with standard error estimates that accounted for inverse probability weighting. Statistical tests were 2-sided at a significance level of .05. The false discovery rate (FDR) based multiple comparison procedure was used to assess the statistical significance of the difference in the change in mortality-related end points (eg, aggregate mortality, mortality with or without readmission) at the FDR level of 0.05.[23,24] Analyses were performed using SAS version 9.4 (SAS Institute).

Results

There were 8 326 688 Medicare fee-for-service hospitalizations for heart failure, acute myocardial infarction, and pneumonia from April 1, 2005, to March 31, 2015, among which 7 948 937 patients were alive at hospital discharge. The mean (SD) age of the study population was 79.6 (8.7) years, 4 246 454 participants (53.4%) were women, 6 802 296 (85.6%) were white, and 738 198 (9.3%) were black. There were 3.2 million hospitalizations for heart failure, 1.8 million for acute myocardial infarction, and 3.0 million for pneumonia and, overall, there were 270 517 deaths from heart failure, 128 088 deaths from acute myocardial infarction, and 246 154 deaths from pneumonia within 30 days of discharge. Baseline patient demographics were similar among the 4 study periods; comorbidities are shown in **Table 1** for patients alive at discharge. Observed trends in 30-day postdischarge and 45-day postadmission outcomes for target conditions are shown in **Figure 2** and eTables 1 and 2 in the Supplement.

HRRP and 30-Day Postdischarge Mortality

Among patients with heart failure, IPW-adjusted postdischarge mortality (**Figure 3**A and eTable 3 in the Supplement) increased before the announcement or implementation of the HRRP (0.27% increase from period 1 to period 2; **Table 2**). Relative to this baseline trend, the announcement of the HRRP was significantly associated with an increase in postdischarge mortality (0.49% increase from period 2 to period 3; 0.22% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .01$). An analysis stratified by whether there was an associated readmission showed that this change was entirely driven by a significant increase in mortality without readmission (0.27% increase from period 1 to period 2 vs 0.53% increase from period 2 to period 3; 0.26% difference between the change from period 1 to period 2 and period 2 to period 3; $P < .001$). In addition, HRRP implementation was significantly associated with an increase in postdischarge mortality overall relative to baseline trends (0.52% increase from period 3 to period 4; 0.25% difference between the change from period 1 to period 2 and period 3 to period 4; $P = .001$), which was also explained by an increase in death without readmission.

In contrast, among patients with acute myocardial infarction (Figure 3B), HRRP announcement was significantly associated with a decline in postdischarge mortality (Table 2; 0.18% increase from period 1 to period 2 vs 0.08% decrease from period 2 to period 3; −0.26% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .01$). Compared with baseline trends, HRRP implementation was not associated with a significant change in mortality (0.15% increase from period 3 to period 4; −0.03% difference between the change from period 1 to period 2 and period 3 to period 4; $P = .69$).

Postdischarge mortality among patients with pneumonia (Figure 3C) was relatively stable before the HRRP (0.04% increase from period 1 to period 2), but increased significantly after announcement of the HRRP (Table 2; 0.26% increase from period 2 to period 3; 0.22% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .01$). This overall change was driven by an increase in patients who were not readmitted but died within 30 days of discharge (0.09% increase from period 1 to period 2 vs 0.32% increase from period 2 to period 3; 0.23% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .003$). In addition, compared with baseline trends, HRRP implementation was also significantly associated with an increase in mortality overall (0.44% increase from period 3 to period 4; 0.40% difference between the change from period 1 to period 2 and period 3 to period 4; $P < .001$) and among stratified mortality outcomes of death and no readmission (0.09% from period 1 to period 2 vs 0.38% from period 3 to period 4; 0.30% difference between the change from period 1 to period 2 and period 3 to period 4; $P < .001$) and readmission and death (0.05% decrease from period 1 to period 2 vs 0.05% increase from period 3 to period 4; 0.11% difference between the change from period 1 to period 2 and period 3 to period 4; $P = .003$).

All P values less than .05 for the 18 comparisons involving 3 end points (total mortality, mortality without readmission, and mortality with readmission), 2 differences in change (post-HRRP announcement trends and post-HRRP implementation trends compared with pre-HRRP trends) and 3 conditions (heart failure, acute myocardial infarction, and pneumonia) were also significant at the FDR level of 0.05 (Table 2).

Other 30-Day Postdischarge Outcomes

Inverse probability-weighted readmissions without death within 30 days declined significantly following the announcement and implementation of the HRRP compared with the years preceding the HRRP for all 3 target conditions (Table 2). Trends across study periods in rates of patients who were not readmitted and were alive within 30 days of discharge are also shown in Table 2 and eTable 3 in the Supplement.

HRRP and 45-Day Postadmission Mortality

Trends in IPW-adjusted postadmission mortality rates are shown in **Figure 4** and eTable 4 in the Supplement. Among patients hospitalized for heart failure, postadmission mortality

Table 1. Baseline Characteristics of Patients Discharged After Hospitalization for Heart Failure, Acute Myocardial Infarction, or Pneumonia[a]

	Participants, %			
	Period 1 (April 2005-September 2007)	Period 2 (October 2007-March 2010)	Period 3 (April 2010-September 2012)	Period 4 (October 2012-March 2015)
Hospitalizations	2 283 774	2 011 915	1 857 337	1 795 911
Demographics				
Age, mean (SD), y	79.5 (8.5)	79.7 (8.7)	79.7 (8.9)	79.6 (9.0)
Women	54.4	53.7	53.1	52.2
Men	45.6	46.3	46.9	47.8
Race/ethnicity				
White	85.9	85.8	85.4	85.1
Black	9.2	9.2	9.4	9.4
Other[b]	4.9	5.0	5.2	5.5
Cardiovascular comorbidities				
Chronic atherosclerosis	53.0	52.6	52.4	50.0
Diabetes	33.9	34.1	35.3	36.0
Hypertension	60.6	66.3	69.1	67.6
History of acute myocardial infarction	5.1	5.2	5.2	5.1
History of heart failure	27.2	26.4	26.8	26.1
Peripheral vascular disease	8.6	8.7	8.4	7.7
Unstable angina	3.4	2.9	2.7	2.6
Valvular heart disease	22.7	17.6	17.2	17.0
Other comorbidities				
Anemia	28.5	30.2	32.3	32.0
COPD	39.6	34.8	34.5	33.8
Cancer	9.5	9.8	9.9	9.7
Cerebrovascular disease	5.1	5.0	4.9	4.5
Dementia	13.7	14.2	12.9	6.8
Depression	8.4	8.1	8.5	8.2
Functional disability	2.9	3.2	3.4	3.3
Liver disease	1.0	1.0	1.1	1.3
Malnutrition	4.6	6.5	7.7	8.2
Psychiatric disorder	2.8	3.2	3.3	3.2
Kidney failure	14.0	18.2	21.2	21.9
Respiratory failure	6.6	8.7	10.2	11.5
Substance abuse	6.9	6.6	7.0	7.3
Trauma	7.5	7.4	7.2	6.6
Length of stay, mean (SD), d	5.6 (4.9)	5.5 (4.8)	5.2 (4.5)	5.1 (4.4)

Abbreviation: COPD, chronic obstructive pulmonary disease.

[a] Data are reported as percentages unless otherwise noted. HRRP announcement was in April 2010 and implementation was in October 2012.

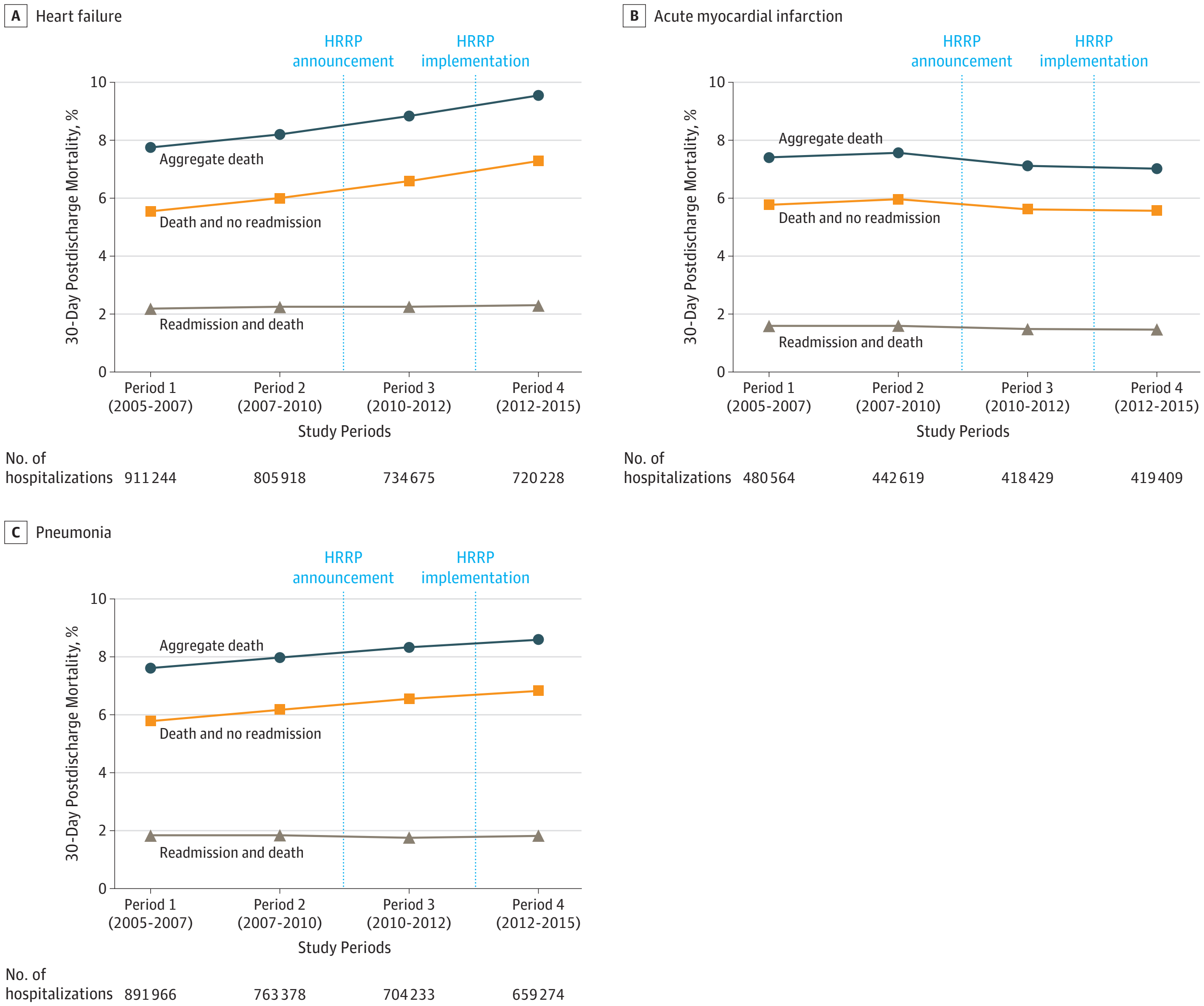
[b] Race/ethnicity denoted as Asian, Hispanic, North American Native, other, or unknown.

rates steadily increased before the announcement of the HRRP (Table 2; 0.15% increase from period 1 to period 2). Compared with this baseline trend, the HRRP announcement was significantly associated with an increase in mortality (0.42% increase from period 2 to period 3; 0.27% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .01$). However, mortality did not significantly change after HRRP implementation (0.32% increase from period 3 to period 4; 0.17% difference between the change from period 1 to period 2 and period 3 to period 4; $P = .06$).

Postadmission mortality declined among patients hospitalized for acute myocardial infarction before the announcement of the HRRP (0.24% decline from period 1 to period 2), a trend that did not significantly change after the HRRP announcement (0.35% decline from period 2 to period 3; −0.12% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .39$). Following the HRRP implementation, postadmission mortality continued to decline (0.44% from period 3 to period 4), but did not significantly differ from baseline trends (−0.21% difference between the change from period 1 to period 2 and period 3 to period 4: $P = .06$).

Among patients hospitalized for pneumonia, postadmission mortality was relatively stable before the HRRP (0.05% increase from period 1 to period 2), and did not significantly change after the HRRP announcement (0.15% decline from period 2 to period 3; −0.20% difference between the change from period 1 to period 2 and period 2 to period 3; $P = .07$) and implementation (0.14% increase from period 3 to period 4; 0.09% difference between the change from period 1 to period 2 and period 3 to period 4; $P = .30$).

Figure 2. Observed 30-Day Postdischarge Mortality for Target Conditions Before and After the Announcement and Implementation of the Hospital Readmissions Reduction Program (HRRP)



Trends in observed overall 30-day postdischarge mortality and 30-day postdischarge mortality stratified by whether there was an associated readmission for (A) heart failure (B) acute myocardial infarction, and (C) pneumonia. Given the large sample size, CIs for all point estimates are very narrow and therefore not depicted.

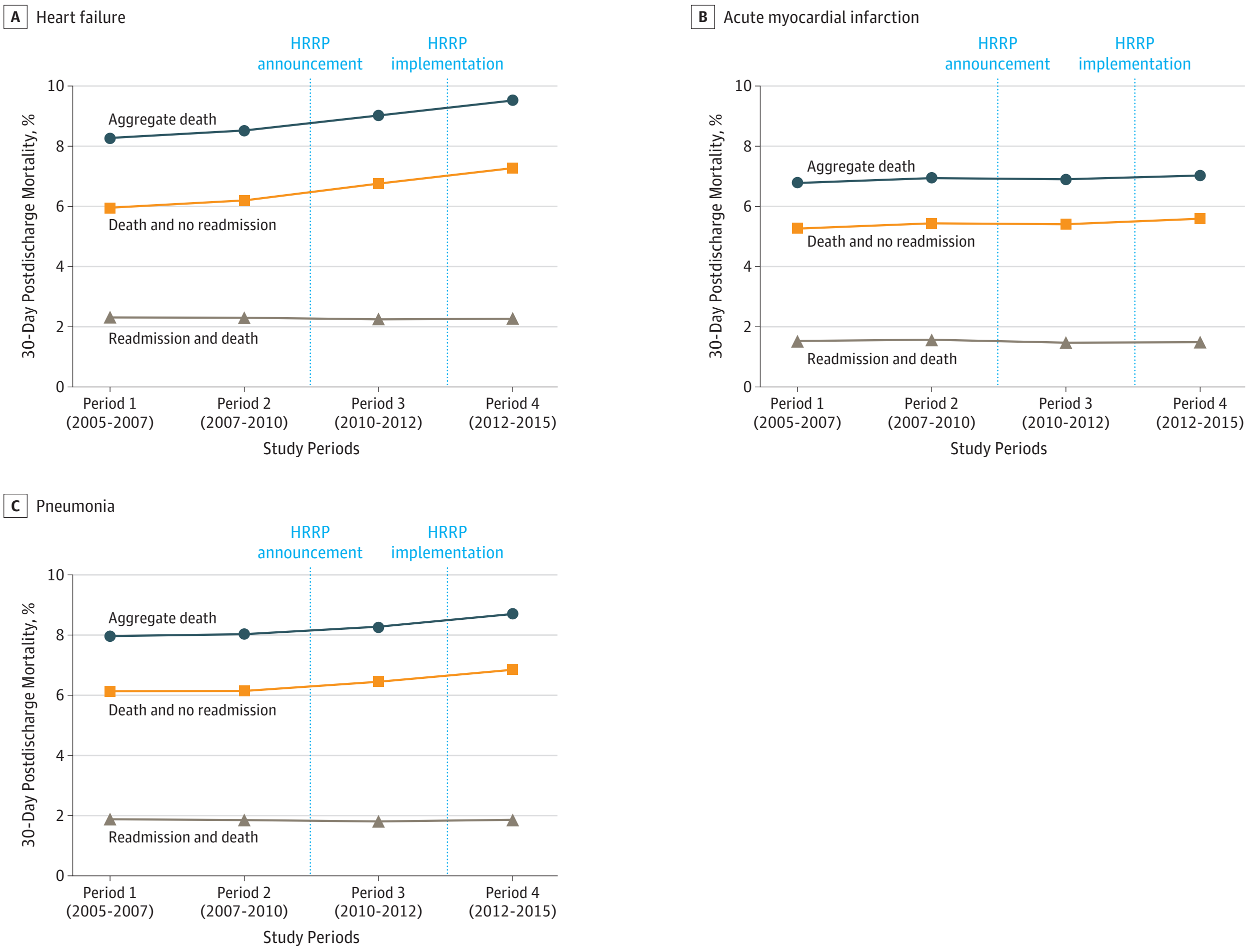
Additional Analyses

As a sensitivity analysis, we excluded patients receiving hospice care and observed patterns in postdischarge mortality that paralleled our primary analysis (eTable 5 in the Supplement). After excluding patients receiving hospice care, postdischarge mortality among patients hospitalized for heart failure and pneumonia were declining before the announcement and implementation of the HRRP, but significantly increased after the announcement and implementation due to an increase in mortality without readmission (eTable 6 in the Supplement). Trends in hospice deaths within 30 days of discharge by condition are shown in eTables 7 and 8 in the Supplement. Trends in postdischarge mortality also remained similar when the analysis was restricted to the first hospitalization for each patient in each period (eTables 9 and 10 in the Supplement) or included all hospitalizations for each patient (eTables 11 and 12 in the Supplement). In addition, findings were consistent using the outcome regression-based approach (eTables 13 and 14 in the Supplement).

Discussion

Overall, the announcement and implementation of the HRRP was associated with a significant increase in mortality within 30 days of discharge among Medicare beneficiaries hospitalized for heart failure and pneumonia, but not for acute myocardial infarction. Although 30-day postdischarge mortality for heart failure was increasing before the HRRP, this increase accelerated after the announcement and implementation of the program. In addition, postdischarge mortality for pneumonia was stable before the HRRP, but increased

Figure 3. Inverse Probability-Weighted 30-Day Postdischarge Mortality for Target Conditions Before and After the Announcement and Implementation of the Hospital Readmissions Reduction Program (HRRP)



Trends in inverse probability-weighted overall 30-day postdischarge mortality and 30-day postdischarge mortality stratified by whether there was an associated readmission. Given the large sample size, CIs for all point estimates were narrow and therefore not depicted (eg, overall mortality for heart failure in period 1 was 8.3% [95% CI, 8.2%-8.4%]).

after announcement and implementation of the program. The increase in mortality for heart failure and pneumonia were driven mainly by patients who were not readmitted within 30 days of discharge.

Postdischarge mortality was first evaluated because this is the period when many potential changes in care incentivized by the HRRP, intended to lower readmissions, could manifest in terms of mortality.[17] In addition, mortality within 45 days of initial admission was also evaluated, because efforts to reduce readmissions could potentially encompass care during the index hospitalization and might influence discharge timing and location of death. Although announcement of the HRRP was associated with a significant increase in mortality for patients with heart failure using this alternate end point, no association was observed between HRRP implementation and increased mortality for all conditions. The difference between findings for postdischarge and postadmission mortality could potentially be explained by in-hospital deaths, which were steadily declining for target conditions in the decade before the announcement and implementation of the HRRP.[25,26] The postadmission mortality measure included both in-hospital and postdischarge deaths; thus secular declines in in-hospital deaths may have counterbalanced the increase in postdischarge mortality observed after the announcement and implementation of the HRRP. Hospitals may have also changed practices so that high-risk patients, over time, were discharged earlier, leading to a shift of some deaths from the inpatient to the outpatient setting that was unrelated to the HRRP. Such shifts, however, would need to have accelerated at the time of the announcement and implementation of the HRRP to explain the concomitant increase in postdischarge mortality.

Most concerning, however, is the possibility that the relationship between the HRRP and postdischarge mortality for heart failure and pneumonia is causal, indicating that the HRRP led to changes in quality of care that adversely affected patients. Financial incentives aimed at reducing readmissions were up to 10- to 15-fold greater under the HRRP

Table 2. Change in Inverse Probability Weighted 30-Day Postdischarge Outcomes and 45-Day Postadmission Mortality

	Outcome, % (95% CI)[a]						
	Baseline	Announcement of the HRRP			Implementation of the HRRP		
	Change From Period 1 to Period 2[b]	Change From Period 2 to Period 3[c]	Difference Between Change From Period 1 to Period 2 and Period 2 to period 3[d]	*P* Value	Change From Period 3 to Period 4[e]	Difference Between Change From Period 1 to Period 2 and Period 3 to Period 4[f]	*P* Value
30-day postdischarge outcomes							
Heart failure							
Aggregate deaths	0.27 (0.16 to 0.38)	0.49 (0.39 to 0.60)	0.22 (0.05 to 0.40)	.01	0.52 (0.41 to 0.62)	0.25 (0.10 to 0.40)	.001
Death and no readmission	0.27 (0.18 to 0.36)	0.53 (0.45 to 0.62)	0.26 (0.11 to 0.41)	<.001	0.51 (0.42 to 0.60)	0.24 (0.11 to 0.37)	<.001
Readmission and death	0.00 (−0.06 to 0.05)	−0.04 (−0.09 to 0.01)	−0.04 (−0.13 to 0.05)	.41	0.01 (−0.05 to 0.06)	0.01 (−0.07 to 0.08)	.83
Readmission and no death	0.37 (0.23 to 0.52)	−0.73 (−0.87 to −0.59)	−1.11 (−1.35 to −0.86)	<.001	−0.64 (−0.77 to −0.50)	−1.01 (−1.21 to −0.81)	<.001
No readmission and no death	−0.64 (−0.85 to −0.44)	0.24 (0.06 to 0.42)	0.88 (0.56 to 1.20)	<.001	0.12 (−0.06 to 0.30)	0.76 (0.49 to 1.03)	<.001
Acute myocardial infarction							
Aggregate deaths	0.18 (0.06 to 0.30)	−0.08 (−0.19 to 0.04)	−0.26 (−0.46 to −0.06)	.01	0.15 (0.03 to 0.26)	−0.03 (−0.20 to 0.13)	.69
Death and no readmission	0.14 (0.03 to 0.24)	0.00 (−0.10 to 0.10)	−0.14 (−0.31 to 0.04)	.12	0.16 (0.05 to 0.26)	0.02 (−0.13 to 0.17)	.79
Readmission and death	0.04 (−0.01 to 0.10)	−0.08 (−0.13 to −0.02)	−0.12 (−0.21 to −0.02)	.02	−0.01 (−0.07 to 0.04)	−0.05 (−0.13 to 0.03)	.19
Readmission and no death	−0.37 (−0.55 to −0.19)	−1.10 (−1.28 to −0.93)	−0.73 (−1.04 to −0.43)	<.001	−1.32 (−1.49 to −1.16)	−0.95 (−1.20 to −0.70)	<.001
No readmission and no death	0.19 (−0.06 to 0.44)	1.18 (0.95 to 1.41)	0.99 (0.59 to 1.39)	<.001	1.18 (0.96 to 1.40)	0.99 (0.65 to 1.32)	<.001
Pneumonia							
Aggregate deaths	0.04 (−0.07 to 0.14)	0.26 (0.16 to 0.36)	0.22 (0.05 to 0.40)	.01	0.44 (0.34 to 0.54)	0.40 (0.26 to 0.55)	<.001
Death and no readmission	0.09 (0.00 to 0.18)	0.32 (0.23 to 0.41)	0.23 (0.08 to 0.38)	.003	0.38 (0.29 to 0.47)	0.30 (0.17 to 0.42)	<.001
Readmission and death	−0.05 (−0.10 to 0.00)	−0.06 (−0.11 to −0.01)	−0.01 (−0.09 to 0.08)	.87	0.05 (0.01 to 0.10)	0.11 (0.04 to 0.18)	.003
Readmission and no death	0.18 (0.05 to 0.32)	−0.20 (−0.33 to −0.08)	−0.39 (−0.61 to −0.16)	<.001	−0.36 (−0.48 to −0.23)	−0.54 (−0.73 to −0.36)	<.001
No readmission and no death	−0.22 (−0.42 to −0.02)	−0.06 (−0.24 to 0.13)	0.17 (−0.16 to 0.49)	.32	−0.08 (−0.26 to 0.09)	0.14 (−0.13 to 0.41)	.30
45-day postadmission mortality							
Aggregate deaths for heart failure	0.15 (0.03 to 0.28)	0.42 (0.30 to 0.54)	0.27 (0.06 to 0.48)	.01	0.32 (0.20 to 0.44)	0.17 (−0.01 to 0.34)	.06
Aggregate deaths for acute myocardial infarction	−0.24 (−0.39 to −0.08)	−0.35 (−0.51 to −0.20)	−0.12 (−0.38 to 0.15)	.39	−0.44 (−0.60 to −0.29)	−0.21 (−0.42 to 0.01)	.06
Aggregate deaths for pneumonia	0.05 (−0.08 to 0.17)	−0.15 (−0.27 to −0.03)	−0.20 (−0.41 to 0.02)	.07	0.14 (0.02 to 0.26)	0.09 (−0.08 to 0.27)	.30

Abbreviation: HRRP, Hospital Readmissions Reduction Program.

[a] Primary outcomes were overall 30-day postdischarge mortality, death without readmission, and death with readmission. Secondary outcomes included readmission and no death, no readmission and no death, and 45-day postadmission mortality.

[b] Baseline absolute change before announcement of the HRRP.

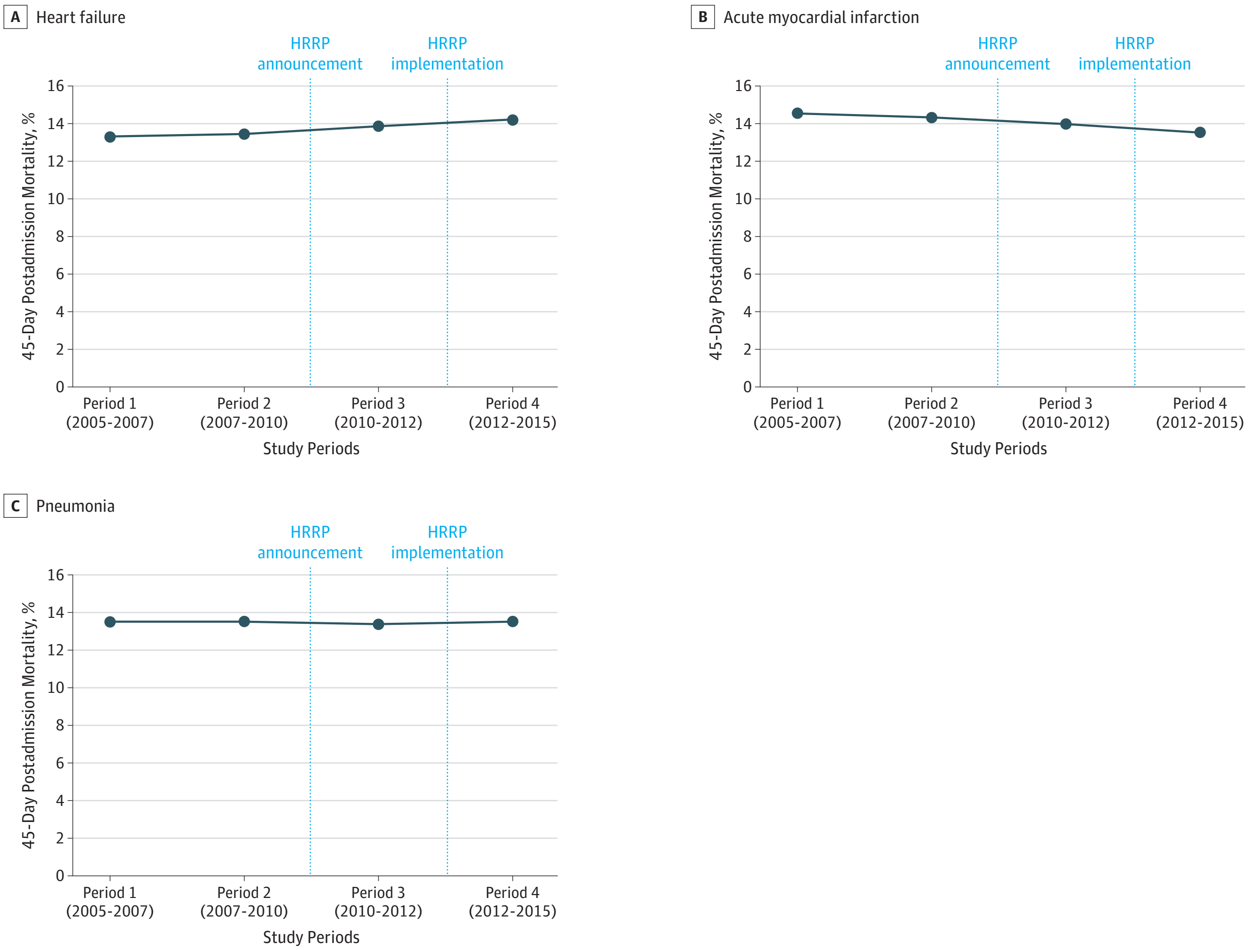
[c] Absolute change after the HRRP announcement.

[d] Difference between the change after the HRRP announcement and the baseline change before the HRRP announcement.

[e] Absolute change after the HRRP implementation.

[f] Difference between the change after the HRRP implementation and baseline change before the HRRP.

Figure 4. Inverse Probability-Weighted 45-Day Postadmission Mortality for Target Conditions Before and After the Announcement and Implementation of the Hospital Readmissions Reduction Program (HRRP)



Trends in inverse probability-weighted 45-day postadmission mortality for (A) heart failure, (B) acute myocardial infarction, and (C) pneumonia. Given the large sample size, CIs for all point estimates are very narrow and therefore not depicted.

than incentives to improve mortality through pay-for-performance programs, and some hospitals may have focused more resources and efforts on reducing or avoiding readmissions than on prioritizing survival. Studies have found little evidence that standard measures of care quality for acute myocardial infarction and heart failure are correlated with readmission rates,[27,28] suggesting that as hospitals face choices about which quality improvement efforts to prioritize, readmissions could be at odds with other goals. Safety net hospitals and hospitals serving a high proportion of socioeconomically disadvantaged patients were more likely to receive financial penalties under the HRRP, potentially impeding their ability to invest limited resources toward quality improvement efforts to better outcomes.[29-32] In addition, the HRRP may have pushed some physicians and institutions to increasingly treat patients who would have benefited from inpatient care in emergency departments or observation units, which could be consistent with the finding that increases in postdischarge mortality for heart failure and pneumonia were entirely driven by patients who were not readmitted within 30 days of discharge. This is also in line with analyses that have shown that following the HRRP, inpatient readmissions declined while emergency department and observation unit stays increased among patients returning to a hospital within 30 days for target conditions.[33]

Alternatively, factors unrelated to the HRRP could potentially explain the observed increases in postdischarge mortality. Greater use of hospice care at the end of life might shift deaths that previously occurred within a hospital to the postdischarge setting over time.[21,22] However, increases in aggregate death and death without readmission were similar even after excluding patients receiving hospice care, indicating that these trends were not explained by greater use of hospice after hospital discharge. Increases in mortality after the announcement and implementation of the HRRP could potentially reflect greater use of do-not-resuscitate orders among hospitalized beneficiaries. In a sample of hospitals in California, for example, the proportion of do-not-resuscitate orders among patients hospitalized for heart failure increased over time.[34] If these patterns were similar on a national scale, trends in mortality might simply reflect greater focus on and attention to goals of care among hospitalized patients or on patients with advanced heart failure increasingly declining life-prolonging care after discharge. It is also possible that the overall increase in postdischarge mortality for heart failure reflects increasing severity of illness among admitted patients that is not captured in claims data. In incentivizing hospitals to not admit patients, the HRRP might have been associated with a change in patients who reached the threshold of admission, resulting in the healthiest portion of these encounters to be managed in the emergency department and observation units and leaving an increasingly higher risk population to be managed in the inpatient setting. Such a shift, if uncaptured in claims, could have led to an increase in mortality after hospitalization for heart failure. In contrast, for pneumonia, recent evidence suggests that shifts in coding practice may have resulted in a healthier cohort of patients over time, because hospitals have increasingly recoded severely ill patients with pneumonia to sepsis or respiratory failure with pneumonia.[35,36] Such shifts in coding make the observed increase in postdischarge mortality among patients with pneumonia less likely to be due to increases in unmeasured disease severity.

The current study builds upon a body of evidence regarding the intended and potential unintended consequences of the HRRP amid recent calls to restructure and improve the program.[5,30,37] Previous work has shown mixed findings regarding the relationship between the HRRP and mortality. A report by the Medicare Payment Advisory Commission demonstrated declines in risk-adjusted mortality since 2008 for all target conditions,[33] which was inconsistent with a number of past analyses that have demonstrated an increase in heart failure and pneumonia mortality rates over the same period.[17-19,38] A 2018 study showed no significant association between the HRRP and increased mortality for target conditions.[39] A third investigation observed a weakly positive correlation between the HRRP and monthly changes in readmissions and postdischarge mortality at the hospital level for all target conditions.[17] Although hospitals that reduce readmissions also appear to reduce mortality, this hospital-level concordance does not reflect the change in readmissions and mortality at the level of the patient population, which is arguably of greater importance to individual patients and to public health. The current analysis is unique in that all Medicare inpatient claims data were used to examine both postadmission and postdischarge mortality at the patient level, stratified outcomes were evaluated to provide mechanistic insights, and an IPW approach was used to compare outcomes among similar patient populations in exposure periods before and after the announcement and implementation of the HRRP.

Limitations

This study has several limitations. First, given the observational design, we are unable to make inferences about causality or the mechanisms that explain the increase in mortality associated with the HRRP for some target conditions. Nevertheless, we attempted to account for secular trends in mortality using baseline years during which the HRRP was not in effect, making it unlikely that observed associations between the HRRP and mortality were due to preexisting trends alone. Second, patient severity of illness may have differed in ways that were not captured by claims data. But, to minimize confounding, we used inverse probability weighting, an approach that is less susceptible to biased estimates of the HRRP's association with mortality due to imbalances in covariates over time. Third, recent studies have demonstrated up-coding associated with the HRRP, although such changes would have attenuated the observed relationship between the HRRP and increased mortality.[40]

Conclusions

Among Medicare beneficiaries, announcement and implementation of the HRRP were significantly associated with an increase in 30-day postdischarge mortality following hospitalization for heart failure and pneumonia, but not for acute myocardial infection. Given the study design and the lack of significant association of the HRRP implementation with mortality within 45 days of hospital admission, further research is needed to understand whether the increase in 30-day postdischarge mortality is a result of the HRRP.

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