

Comparison of the change in heart failure readmission and mortality rates between hospitals subject to hospital readmission reduction program penalties and critical access hospitals



Alexander T Sandhu, MD, MS,^a and Paul A Heidenreich, MD, MS^{a,b} *Stanford, and Palo Alto, CA*

Background The Hospital Readmission Reduction Program (HRRP), announced in 2010, penalizes hospitals with high readmissions for multiple conditions including heart failure.

Methods We compared heart failure readmission and mortality rates in hospitals exposed to HRRP financial penalties with critical access hospitals (CAHs) not subject to the penalty between 2005 and 2016 using 3-year moving averages from Hospital Compare.

Results After HRRP introduction, CAHs experienced a 0.60% annual decrease (95% CI: -0.61 to -0.59%) in heart failure readmissions. HRRP-exposed hospitals experienced an additional 0.13% annual decrease (95% CI: -0.14 to -0.12%) compared with CAHs. The association between HRRP penalties and mortality varied with model specifications.

Conclusions Using CAHs as a control group, we found the introduction of financial penalties was only associated with modest reductions in readmissions and an uncertain association with mortality. Cluster-randomized rollouts of health care policy interventions will allow us to better evaluate the impact of our interventions. (*Am Heart J* 2019;209:63-67.)

The Hospital Readmission Reduction Program (HRRP) introduced financial penalties for hospitals with high 30-day readmission rates for Medicare patients admitted for heart failure, acute myocardial infarction, or pneumonia.¹ While multiple studies have demonstrated a reduction in heart failure readmissions, the effect of HRRP on heart failure mortality remains controversial.^{2,3}

Isolating the effect of a health policy intervention is challenging due to potential confounders. Other policy interventions, changes in heart failure management, or an increased national focus on readmissions may have also influenced temporal changes. Thus, the relative impact of HRRP's financial penalties as opposed to other factors is less clear.

A subset of acute inpatient hospitals termed "critical access hospitals (CAHs)" is exempt from HRRP penalties.

The designation of CAHs was developed in 1997 in response to rural hospital closures.⁴ To qualify, a hospital must have fewer than 25 acute care inpatient beds, provide 24-hour emergency care services, and have an average annual length of stay less than 96 hours.⁵ CAHs are typically located in rural areas and must either be a given distance from other hospitals (35 miles by primary roads or 15 miles by secondary roads) or have been designated a "necessary provider" by their state before 2006. CAHs are paid 101% of allowable costs instead of using the Inpatient Prospective Payment System (IPPS); therefore, they are not exposed to programs like HRRP that adjust this payment.^{4,5}

We compared heart failure outcomes in hospitals exposed to penalties with CAHs not subjected to penalties to evaluate the impact of HRRP penalties on readmission and mortality.

Methods

Hospital-level, risk-adjusted 30-day readmission and mortality rates after hospitalizations for heart failure were extracted from the Hospital Compare website (publicly available Medicare database).⁶ We used annually updated, 3-year moving averages between 2005 and

From the ^aStanford University School of Medicine, Stanford, CA, and ^bVeterans Affairs Palo Alto Health Care System, Palo Alto, CA.

Submitted December 3, 2018; accepted December 3, 2018.

Reprint requests: Alexander T. Sandhu, MD, MS, 300 Pasteur Drive, Stanford, CA 94305.

E-mail: Ats114@stanford.edu

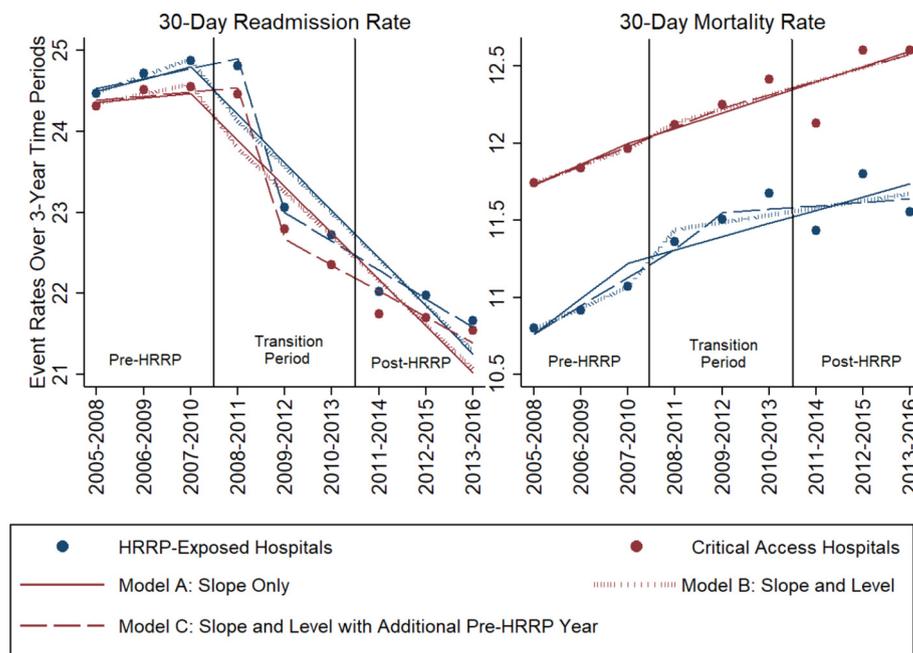
Twitter: @ATSandhu (A.T. Sandhu).

0002-8703

© 2018 Elsevier Inc. All rights reserved.

<https://doi.org/10.1016/j.ahj.2018.12.002>

Figure 1



Changes in Heart Failure Readmission and Mortality Rates. Figure 1 displays the 3-year weighted average of 30-day readmission and mortality rates in hospitals exposed to HRRP financial penalties (HRRP-exposed Hospitals) and Critical Access Hospitals. Predicted values based on each of the three models are graphed for both outcomes. The graph is divided into pre-HRRP – 3-year time periods prior to the announcement of the program, the transition period – years pre-HRRP and years after HRRP establishment but without active financial penalties, and post-HRRP – 3-year periods limited to after the program was announced. In models A and B, the transition period was included as post-HRRP because it included years after establishment of the program. In a sensitivity analysis we included 2008–2011 as an additional pre-HRRP year (model D).

2015. Since cohorts include data over 3-year periods, several cohorts overlapped with the launch of HRRP. The program was announced in 2010 with penalties starting in October 2012. We assumed outcomes from 2005 to 2008 through 2007 to 2010 cohorts were pre-HRRP and outcomes from 2008 to 2011 to 2013 to 2016 cohorts were post-HRRP.

We compared HRRP-exposed hospitals (HEHs) with critical access hospitals (CAHs) – generally small, rural hospitals—that voluntarily reported outcomes but were not subjected to financial penalties.⁷ We excluded hospitals with missing rates. Missing rates may be due to an inadequate patient volume or a decision to not share data for hospitals participating voluntarily.

Sample means were compared using the two-sample t-test. We performed a controlled, interrupted time-series analysis using two different model structures and hospital fixed effects. First, we compared the rate of change (Model A) before and after HRRP introduction. Second, we included a one-time change in the period post-HRRP and a change in the slope (Model B). In a sensitivity analysis, we repeated both models with 2008–2011 in the pre-HRRP period (Models C and D). We also evaluated the hospital-level correlation between changes in readmis-

sion and changes in mortality in HEHs and CAHs post-HRRP.

Results

Complete data were available for 448 of 1010 (44.4%) CAHs certified since before 2005 and 2746 HEHs (66.8% of those on Hospital Compare). In the first period (2005–2008), 30-day heart failure readmission rates were significantly higher in HEHs than CAHs (24.5% vs 24.3%, $P = .01$) while 30-day mortality rates were significantly lower (11.1% vs 11.7%, $P < .01$).

Risk-adjusted 30-day readmission

Readmission rates trended upward in both HEHs and CAHs prior to HRRP with trends decreasing for both post-HRRP (Figure 1). In CAHs, the annual change in readmission rates significantly decreased from an annual 0.03% increase pre-HRRP to an annual decrease of -0.57% post-HRRP (Table D). In HEHs, annual increases of 0.15% decreased to -0.58% annually. Compared with CAHs, HEHs experienced an additional -0.13% (95% CI: -0.14 to -0.12%) annual change in readmission rates post-HRRP.

Table I. Change in 30-day Heart Failure Readmission (%) After HRRP Implementation in HEHs and CAHs^{1,2}

	30-d Readmission rate (%)			
	Model A ³	Model B ⁴	Model C ⁵	Model D ⁶
Difference in HEHs compared with CAHs				
Additional Annual Change, pre-HRRP (B ₂)	0.12* (0.11 to 0.13)	0.12* (0.11 to 0.12)	0.08* (0.07 to 0.08)	0.10* (0.10 to 0.11)
Additional Annual Change, post-HRRP (B ₄)	-0.13* (-0.14 to -0.12)	-0.13* (-0.14 to -0.12)	-0.09* (-0.10 to -0.08)	-0.11* (-0.12 to -0.11)
Additional Change in Year after HRRP (D ₀)	—	0.03* (0.01 to 0.05)	—	-0.08 (-0.10 to -0.06)
Change in CAHs				
Annual Change, pre-HRRP (B ₁)	0.03* (0.03 to 0.04)	0.10* (0.09 to 0.10)	-0.19* (-0.20 to -0.19)	0.03* (0.02 to 0.03)
Additional Annual Change, post-HRRP (B ₃)	-0.60* (-0.61 to -0.59)	-0.63* (-0.64 to -0.62)	-0.39* (-0.40 to -0.38)	-0.35* (-0.36 to -0.34)
Change in Year after HRRP (C ₀)	—	-0.23* (-0.25 to -0.22)	—	-1.47* (-1.48 to -1.45)

¹ Abbreviations: HEH: HRRP-exposed Hospitals; HRRP: Hospital Readmission Reduction Program.

² Hospitalization rates are annual 3-year, risk-adjusted moving averages from Hospital Compare.

³ Slope Model: $Y_{ij} = (B_1 * Year_j) + (B_2 * Year_j * H) + (B_3 * Year_k) + (B_4 * Year_k * H) + Z_i + \epsilon_{ij}$ where Y_{ij} is outcome rate for a given hospital i and year j . $Year_j$ is the number of years into the model. $Year_k$ is the number of years post-HRRP implementation and is 0 pre-HRRP implementation. H is a dummy variable that equals 1 for hospitals exposed to financial penalties. Z_i is a hospital-specific intercept. ϵ represents the error term.

⁴ Slope and Level Model: $Y_{ij} = (B_1 * Year_j) + (B_2 * Year_j * H) + (B_3 * Year_k) + (B_4 * Year_k * H) + Z_i + C_0 * HRRP_{post} + (D_0 * HRRP_{post} * H) + \epsilon_{ij}$ where $HRRP_{post}$ is a dummy variable that equals 1 in any year post-HRRP. The remainder of the formula is the same as in "slope" model above.

⁵ Same structure as "slope" model above except 2008–2011 is included as a pre-HRRP year.

⁶ Same structure as "slope and level" model above except 2008–2011 is included as a pre-HRRP year.

Table II. Change in 30-day heart failure mortality (%) after HRRP implementation in HEHs and CAHs^{1,2}

	30-day Mortality Rate (%)			
	Model A ³	Model B ⁴	Model C ⁵	Model D ⁶
Difference in HEHs compared with CAHs				
Additional Annual Change, pre-HRRP (B ₂)	0.08* (0.08 to 0.09)	-0.01* (-0.01 to 0.00)	0.04* (0.04 to 0.05)	0.04* (0.04 to 0.05)
Additional Annual Change, post-HRRP (B ₄)	-0.08* (-0.09 to -0.08)	-0.03 (-0.04 to -0.02)	-0.12* (-0.12 to -0.11)	-0.12* (-0.12 to -0.11)
Additional Change in Year After HRRP (D ₀)	—	0.31* (0.30 to 0.33)	—	0.28* (0.27 to 0.30)
Change in CAHs				
Annual Change, pre-HRRP (B ₁)	0.16* (0.16 to 0.17)	0.15* (0.14 to 0.16)	0.15* (0.14 to 0.15)	0.15* (0.14 to 0.15)
Additional Annual Change, post-HRRP (B ₃)	-0.08* (-0.09 to -0.07)	-0.02* (-0.03 to -0.01)	-0.06* (-0.07 to -0.06)	-0.06* (-0.07 to -0.06)
Change in Year after HRRP (C ₀)	—	0.04* (0.03 to 0.05)	—	-0.05* (-0.06 to -0.03)

¹ Abbreviations: HEH: HRRP-exposed Hospitals; HRRP: Hospital Readmission Reduction Program.

² Mortality rates are annual 3-year, risk-adjusted moving averages from Hospital Compare.

³ Slope Model: $Y_{ij} = (B_1 * Year_j) + (B_2 * Year_j * H) + (B_3 * Year_k) + (B_4 * Year_k * H) + Z_i + \epsilon_{ij}$ where Y_{ij} is outcome rate for a given hospital i and year j . $Year_j$ is the number of years into the model. $Year_k$ is the number of years post-HRRP implementation and is 0 pre-HRRP implementation. H is a dummy variable that equals 1 for hospitals exposed to financial penalties. Z_i is a hospital-specific intercept. ϵ represents the error term.

⁴ Slope and Level Model: $Y_{ij} = (B_1 * Year_j) + (B_2 * Year_j * H) + (B_3 * Year_k) + (B_4 * Year_k * H) + Z_i + C_0 * HRRP_{post} + (D_0 * HRRP_{post} * H) + \epsilon_{ij}$ where $HRRP_{post}$ is a dummy variable that equals 1 in any year post-HRRP. The remainder of the formula is the same as in "slope" model above.

⁵ Same structure as "slope" model above except 2008–2011 is included as a pre-HRRP year.

⁶ Same structure as "slope and level" model above except 2008–2011 is included as a pre-HRRP year.

The model also incorporating an immediate post-HRRP change in readmission rates (model B) led to similar results (Table I). We repeated both models while

including 2008–2011 in the pre-HRRP period (Models C and D). Although this graphically fit the data better, this had negligible effects on the results.

Risk-adjusted 30-day mortality

Mortality rates were increasing prior to the institution of HRRP (Table II). In both CAHs and HEHs, mortality continued to increase; however, the annual change in mortality decreased post-HRRP. For HEHs, the annual change in mortality rate went from a 0.24% annual increase to a 0.08% annual increase. Compared with CAHs, the annual change in mortality in HEHs was -0.08% (95% CI: -0.09 to -0.08%) post-HRRP.

With Model B, there was a 0.04% (95% CI: 0.03 to 0.05%) increase in mortality in CAHs in the initial period post-HRRP. In comparison with CAHs, HEHs experienced an additional 0.31% (95% CI: 0.30–0.33%) increase in mortality at the time of HRRP implementation. However, the annual change in mortality (the slope) still decreased by -0.03% (95% CI: -0.04 to -0.02%) compared with CAHs post-HRRP. After including 2008–2011 as a pre-HRRP year (Model D), the initial increase in mortality post-HRRP (0.28%; 95% CI: 0.27–0.30) remained. However, the change in mortality decreased to -0.12% (-0.12 to -0.11%) annually. With this model, HRRP was associated with decreased mortality by year 3.

The correlation between the change in readmission and change in mortality was small for both HEHs (0.05) and CAHs (0.08) after HRRP introduction.

Discussion

Readmission rates decreased after HRRP introduction both for hospitals subjected to financial penalties and those that were not. The difference in post-HRRP readmission rates between CAHs and HEHs was small compared with the decrease in CAHs. This suggests direct exposure to financial penalties was not solely responsible for the observed decrease in readmissions. In hospitals exposed to penalties, we found an initial increase in mortality after HRRP along with a smaller decrease in the annual change in mortality.

Given much of the reduction in readmissions post-HRRP was also seen in CAHs, factors independent of the financial penalties likely contributed. For example, improvement in heart failure management may have been partially responsible for the observed decreases in readmissions. The general focus on public reporting and hospital rankings, often influenced by readmission metrics, may have also impacted readmission patterns independent of HRRP. Alternatively, there may have been substantial spillover effect of the policy onto CAHs. The national focus on readmissions may have increased emphasis on interventions such as early post-discharge follow-up or outpatient monitoring that reduced readmission in CAHs.

Our findings illustrate the complexity of evaluating HRRP's impact on mortality and are consistent with prior literature. Gupta et al demonstrated post-discharge heart failure mortality increased after HRRP in a subset of

Medicare beneficiaries using an interrupted time-series analysis.² Our second model (model B) also demonstrated an increase in mortality after HRRP introduction in comparison with CAHs. Although this found HRRP was associated with a decrease in annual mortality change, this was overshadowed by the magnitude of the initial mortality increase. Dharmarajan et al performed a hospital-level analysis that also found heart failure mortality was increasing after HRRP.⁸ However, like our analysis, they showed mortality rates were increasing before HRRP introduction and hospitals with decreasing readmissions did not experience an increase in mortality.

Heart failure mortality may have initially increased in hospitals exposed to HRRP. However, we found such an association was sensitive to model specifications. Attributing the increased mortality to HRRP is less credible because of the lack of an inverse association between changes in readmission and mortality.

Evaluating HRRP is challenging due to difficulties in pinpointing its onset and isolating its effect. Prior analyses assumed the impact of HRRP started when the law was passed, but hospitals may have required time to react to the program. Including an additional year as pre-HRRP led to larger annual decreases in mortality offsetting the initial mortality increase. Because our analysis used 3-year moving average outcome rates, it is more difficult to use annual trends alone to isolate the impact of HRRP. However, our analysis compared temporal changes between CAHs and penalty-exposed hospitals.

Our analysis differed from prior literature by including mortality during the index admission and including a control group not exposed to the financial penalty. Without a control, it is unclear if temporal changes are secondary to the intervention or other concurrent factors that may influence mortality rates. For example, the Recovery Audit Contractor Program, introduced in 2010, increased the pressure on hospitals to reduce less severe, short-duration admissions.^{9,10} Reducing less severe index admissions would also increase expected 30-day mortality.

There are important limitations regarding CAH controls. First, these hospitals often care for patients with important socioeconomic challenges such as poverty that are not accurately captured in the risk adjustment model. Previous research has demonstrated higher heart failure mortality rates at CAHs compared with non-CAH controls.¹¹ Given their limited resources, there may also be delays with implementing new therapies. These factors could introduce other time-varying effect that differentially impact outcomes. Second, CAHs voluntarily publicly report outcomes, with a lower proportion having complete data over our study period. This may lead to the higher performing CAHs in our control group, which would bias against HRRP. Finally, CAHs are paid with cost-based reimbursement instead of Medicare Severity Diagnosis Related Groups. This may cause important differences in coding severity of illness.

Changes in heart failure readmission post-HRRP were shared by hospitals exempt from financial penalties. It remains unclear if this is due to spillover effects from HRRP or alternate forces at play driving decreases in readmission. Nonetheless, this supports the need for further attention and study on the impact of financial incentives based on readmission rates. Our results provide further context to the debate regarding the impact of readmissions penalties on mortality by incorporating a control group. We believe this ongoing discussion illustrates the incredibly difficult challenge of isolating the effect of a broad health care policy from the many simultaneously changing influences in the clinical and policy realms. Investing in cluster-randomized trials of such interventions may be necessary to more clearly see the way forward.

References

1. McIlvennan CK, Eapen ZJ, Allen LA. Hospital readmissions reduction program. *Circulation* 2015;131:1796-803.
2. Gupta A, Allen LA, Bhatt DL, et al. Association of the Hospital Readmissions Reduction Program Implementation With Readmission and Mortality Outcomes in Heart Failure. *JAMA Cardiol* 2018;3:44-53.
3. Chatterjee P, Joynt Maddox KE. US national trends in mortality from acute myocardial infarction and heart failure: policy success or failure? *JAMA Cardiol* 2018;3(4):336-40.
4. Medpac. Critical Access Hospitals Payment System. http://medpac.gov/docs/default-source/payment-basics/medpac_payment_basics_17_cah_final09a311adfa9c665e80adff00009edf9c.pdf?sfvrsn=0. Accessed September 16, 2018.
5. Center for Medicare and Medicaid Services. Critical Access Hospital. <https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/downloads/CritAccessHospfctshht.pdf>. Accessed September 16, 2018.
6. Center for Medicare and Medicaid Services. Hospital Compare. <https://www.medicare.gov/hospitalcompare/search.html?> Accessed March 1, 2018.
7. Flex Monitoring Team. Critical Access Hospital Locations. <http://www.flexmonitoring.org/data/critical-access-hospital-locations/>. Accessed March 1, 2018.
8. Dharmarajan K, Wang Y, Lin Z, et al. Association of Changing Hospital Readmission Rates With Mortality Rates After Hospital Discharge. *JAMA* 2017;318:270-8.
9. Feng Z, Wright B, Mor V. Sharp rise in Medicare enrollees being held in hospitals for observation raises concerns about causes and consequences. *Health Aff (Millwood)* 2012;31:1251-9.
10. Centers for Medicare and Medicaid Services. Medicare Fee for Service Recovery Audit Program. <https://www.cms.gov/research-statistics-data-and-systems/monitoring-programs/medicare-ffs-compliance-programs/recovery-audit-program/>. Accessed August 1, 2018.
11. Joynt KE, Harris Y, Orav EJ, et al. Quality of care and patient outcomes in critical access rural hospitals. *JAMA* 2011;306:45-52.