# A Statistical Analysis of Penalty vs. Incentive Designs for Hospital Readmission

**Abstract ID: 627068**

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## Abstract

The Hospital Readmission Reduction Program (HRRP) aims to reduce the rate of hospital readmissions in the U.S. A hospital readmission occurs when a patient is admitted to a hospital within 30 days of discharge from a previous stay. HRRP applies a penalty mechanism to reimbursements payments from the Centers of Medicare and Medicaid Services (CMS) to the hospital base on the hospital's excess readmission ratio (ERR). Critics of HRRP point out that hospitals with poor readmission rates are receiving less money to make meaningful changes, widening the disparity gap. Therefore, this study proposes two new mechanism designs for consideration in the HRRP by incorporating a financial incentive. We present a statistical analysis comparing the two new incentive mechanism designs to the current HRRP penalty mechanism design. We report the expected impact of the new policies based on FY 2018 CMS data. Our results show that less than 4% of hospitals in each peer group received the maximum penalty for FY 2018 under current penalty mechanism while 93-96% of hospitals would be eligible for receiving incentives in our proposed incentive mechanism. Moreover, a reduction between 30-42% of penalized hospitals across all peer groups are available by moving to the hybrid mechanism.

## Keywords
Hospital Readmission, Health Policy, Medicare Reimbursement, HRRP Mechanism Design

## 1. Introduction
A hospital readmission occurs when a patient is admitted to an inpatient acute care facility within 30 days after being discharged from an earlier inpatient stay [1]. Significant percentage of the gross domestic product (GDP) in both developed and developing countries belongs to health care expenses [2]. In recent years, the substantial readmission costs of hospitals have become a significant topic in U.S. healthcare system [3]. The Centers for Medicare and Medicaid Services (CMS) established the Hospital Readmission Reduction Program (HRRP) in 2012 to reduce high readmission rates and readmission costs in hospitals [1]. CMS adopted a penalty mechanism for hospitals that performed under the risk-adjusted median for readmission rate among the hopsital's peer group. To compute these measures for each peer group, CMS evaluates three years of performance history for each hospital within the peer group, by computing the hospital's excess readmission ratio (ERR) and weighting that across six conditions. The six conditions are acute myocardial infarction (AMI), pneumonia (PN), heart failure (HF), elective primary total hip and/or total knee arthroplasty (HK), chronic obstructive pulmonary disease (COPD), and coronary artery bypass graft (CABG) surgeries. CMS has been modifying the HRRP policy annually with incremental changes. For example, the readmission penalty was raised from 1% in FY 2013 to 3% in FY 2015 [1]. Additional conditions have been added, too, and Table 1 shows a summary of the HRRP progression for health conditions and maximum penalty for each year. The development of the peer group model (as opposed to only having one large group) has been the most recent development. Since HRRP continues to evolve regularly, this paper takes the opportunity to do a statistical analysis on the impact of developing a new HRRP mechanism designs which utilize incentives, or positive reinforcement, instead of penalties, or negative reinforcement.

There are several motivations for the development of the new HRRP mechanism designs. First, the current HRRP penalty mechanism fails to provide financial support to hospitals that are already struggling with poor readmission

rates. Second, evidence has shown that readmission rates have dropped since the implementation of the HRRP program, but many believe that this has been in response to gaming of the system. In the same period, there has been an increase in intentional delays in readmissions beyond 30 days and inappropriate triage strategies in emergency departments [4]. Furthermore, a series of independent reports indicated that implementation of the HRRP has actually increased heart failure mortality after a decade of decline [4]. Finally, the positive reinforcement that the Medicare Shared Savings Programs has for accountable care organizations [5] is a motiviating factor for exploring alternative mechanisms designs, including non-punitive strategies that align the objectives of the hospitals and the insurers.

Table 1: Health conditions and maximum penalty by year

| **FY 2013** | **FY 2014** | **FY 2015-2016** | **FY 2017 - present** |
|---|---|---|---|
| AMI | AMI | AMI | AMI |
| PN | PN | PN | PN |
| HF | HF | HF | HF |
| | | HK | HK |
| | | COPD | COPD |
| | | | CABG |
| 1% | 2% | 3% | 3% |

In the literature, there are several others working on analysis of the HRRP mechanism design. Zhang et al. [6] presented a game-theoretic model to analyze the HRRP from operational and economic perspectives. They showed that HRRP not always provides any incentive for the hospitals to reduce their readmission rate, and competition between hospitals can even increase the number of hospitals to reduce their readmission rate. They only showed the hospitals prefer to pay more penalties to reduce readmissions. However, they do not provide any incentive scheme in their analysis. Feemster and Au [7] stated that readmission measure itself does not provide an incentive for a high-quality of accountability. Alvarado et al. [8] developed a penalty-incentive model for hospital readmissions in a basic game theoretic setting between an insurer and hospital. They analyzed the HRRP mechanism design using centralized and decentralized control and identified the Win-Win region for the penalty-incentive factor. Their results revealed that CMS should move to an incentive policy to increase quality of care.

In this paper, we propose two new HRRP mechanism designs. The first design is an incentive mechanism that rewards hospitals with good readmission rate. The second is a hybrid mechanism that combines the extremes of the current penalty mechanism and the proposed incentive mechanisms. In this paper, we then perform a statistical analysis on the three mechanism designs to compare the outcomes. The rest of this paper is organized as follows: Section 2 provides an overview of problem description and proposed mechanisms. Section 3 describes statistical analysis on mechanisms and compare their performances. Finally, section 4 describes the summary and concluding remarks.

## 2. Problem Description

In this section, we first describe the current HRRP penalty mechanism design. Next, we introduce an incentive mechanism design, and then a hybrid of the two extremes.

**Penalty Mechanism:**

The HRRP penalty mechanism imposes a penalty on the reimbursement payment from CMS to the hospitals with poor readmission rates. Recall that CMS computes an ERR score for each hospital for each of the six HRRP conditions. An ERR is the ratio of predicted-to-expected readmission for a given condition. Conditions with fewer than 25 eligible discharges at the hospital are discarded. Effective in FY 2019, CMS began classifying hospitals into five peer groups based on the hospital's dual proportion, or the proportion of medicare fee-for-service (FFS) and managed care stays where the patient was dually eligible for Medicare and full-benefit Medicaid. Hospitals in the first peer group have the lowest dual proportion and hospitals in the $5^{th}$ peer group have the highest dual proportion. Next, the median ERR for each peer group condition is identified ($Median\,peer\,group\,ERR_c$). High ERR scores are indicators of poor readmission rates while low ERR scores are indicators of good readmission rates. Any condition with an ERR which has not been excluded the computation of the penalty factor for the hospital. The penalty factor is a weighted average of the remaining ERR scores for each HRRP condition at the hospital. The weighted average is based on operating $DRG\,Payment_c$ for each condition $c$. A DRG (diagnostic-related group) is how Medicare and certain health insurance

companies consider hospitalization costs and determine how much to pay for a hospital stay. Each DRG has a payment weight assigned to it and was available in the data source [9]. The maximum penalty is 3%, and the final value is subtracted from 1. Finally, the penalty factor ($f_1$) for each hospital can be obtained by equation 1:

$$f_1 = 1 - min\left\{0.03, \sum_c \frac{DRG\,Payment_c * max\{ERR_c - Median\,peer\,group\,ERR_c, 0\}}{All\,DRG\,payments}\right\}. \tag{1}$$

where $c$ in these equations is any one of the six conditions: AMI, PN, HF, HK, COPD, and CABG with 25 or more eligible discharges. The *All DRG payments* are based on total payments by year outside the six HRRP conditions. The penalty factor is then a value in the interval [0.97,1.00]. Thus, a hospital's reimbursement payment from CMS is multiplied by their penalty factor. Hospitals with a penalty factor of 1.00 receive the highest level of payment (or no penalty), whereas others may have the maximum penalty of 3% when their penalty factor is 0.97.

**Incentive Mechanism:**

The extension to the incentive mechanism design is very natural. We still compute ERR values by condition for each hospital, define a peer group median, and exclude conditions with less than 25 eligible discharges. However, we edit the equation to favor the higher ERR scores to be considered by switching the terms $ERR_c$ and $Median\,peer\,group\,ERR_c$. The incentive factor ($f_2$) is then can be calculated by equation 2. The differences in $f_1$ and $f_2$ are that ERR and median flipped and also the sign is plus.

$$f_2 = 1 + min\left\{0.03, \sum_c \frac{DRG\,Payment_c * max\{Median\,peer\,group\,ERR_c - ERR_c, 0\}}{All\,DRG\,payments}\right\} \tag{2}$$

The incentive factor is then a value in the interval [1.00,1.03]. A hospital's reimbursement payment from CMS would still be multiplied by their incentive factor. Hospitals with an incentive factor of 1.03 receive the highest level of payment (maximum incentive), whereas others may have the usual payment when their incentive factor is 1.00.

**Hybrid Mechanism:**

Next, the proposed hybrid factor $f$ is a convex combination of the $f_1$ penalty factor and the $f_2$ incentive factor. The hybrid factor is given by equation 3:

$$f = w_1 * f_1 + w_2 * f_2. \tag{3}$$

where $w_1$ and $w_2$ are penalty and incentive weights respectively. They can be obtained by equations 4 and 5:

$$w_1 = \frac{\sum_c \{DRG\,Payment_c * max\{ERR_c - Median\,peer\,group\,ERR_c, 0\}\}}{\sum_c DRG\,Payment_c * |ERR_c - Median\,peer\,group\,ERR_c|}, \tag{4}$$

$$w_2 = \frac{\sum_c \{DRG\,Payment_c * max\{Median\,peer\,group\,ERR_c - ERR_c, 0\}\}}{\sum_c DRG\,Payment_c * |ERR_c - Median\,peer\,group\,ERR_c|}. \tag{5}$$

The hybrid factor is then a value in the interval [0.97,1.03]. A hospital's reimbursement payment from CMS would still be multiplied by their hybrid factor. Hospitals with a penalty factor of 1.03 receive the highest level of payment (maximum incentive), whereas others may have the lowest level of payment under a hybrid factor of 0.97.

Figure 1 shows the summary of the penalty/incentive/hybrid computation approach, broken into four main steps. In step 1, hospitals submit their claims data to Medicare. In step 2, the ERR is calculated for the six HRRP conditions for each hospital. For step 3, each the median ERRs for each peer group are calculated, after excluding values for hospitals with less than 25 eligible discharges for a condition. Finally, in step 4 the penalty and incentive factors ($f_1, f_2$) are calculated by equations 1 and 2. The hybrid factor ($f$) can then be calculated based on equation 3.

## 3. Statistical Analysis

We now present a statistical analysis and the impact of the three mechanisms. We analyze data from fiscal year (FY) 2018 which is from July 2013 to June 2016 as reported by [1]. A total of 3182 hospitals were evaluated for FY 2018. We investigate two statistical analysis for all hospitals by peer group. First, we present a **histogram** to show the distribution of all hospitals receiving penalties and/or incentives for each mechanism design. We also summarize the **percentage** of hospitals falling into penalty or incentive positions by peer group and mechanism design.

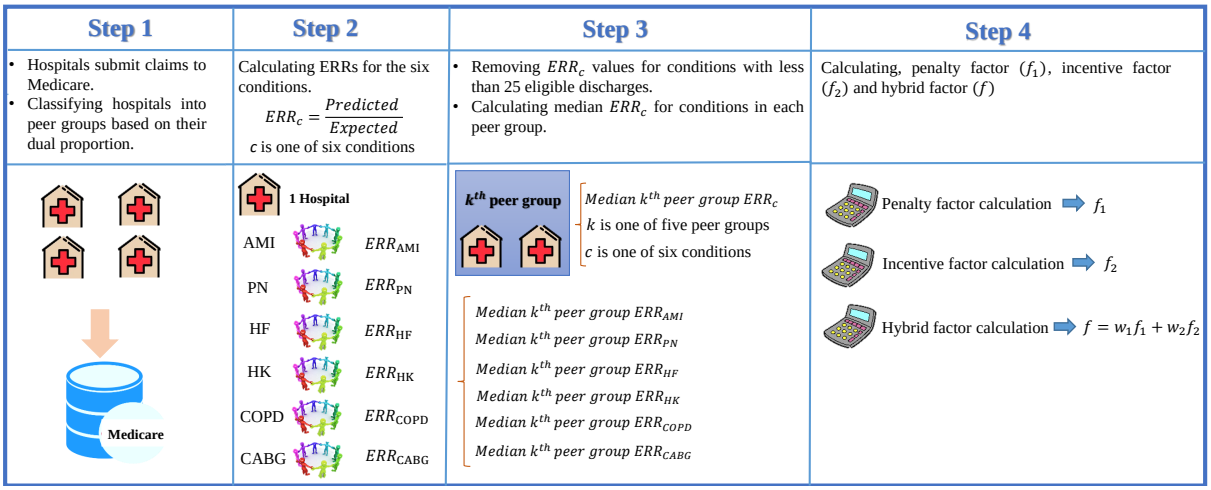


Figure 1: Four steps of proposed evaluation approach

### 3.1 Histogram

The first statistical analysis studies the distribution of all hospitals in each peer group under penalty, incentive and hybrid mechanisms. These distributions for each peer group are shown in Figure 2. Each bar of the histrogram represents a bin, and the label corresponds to the right end-point of the interval. For example, consider the penalty mechanism for peer group 1: the histogram bar with 106 hospitals and the label 0.995 should be interpreted as 106 hospitals have a penalty factor of (0.990,0.995].

Under the penalty mechanism, most hospitals are avoiding or getting a very small penalty. There is a shared, stair-stepping increase in the number of hospitals as the move from left (maximum penalty) to right (avoiding the penalty). Only a few hospitals are getting the maximum penalty ($\approx$ 0-4% across all peer groups). Under the incentive mechanism, 1-11% of hospitals are receiving the highest level of payment (maximum incentive) and only 3-6% of hospitals may have the usual payment level across all peer groups. To shift to the hybrid mechanism, the distribution closely follows a central tendency of normal or triangular distribution and the number of penalized hospitals reduces. Moreover, the first peer group has the highest number of hospitals with maximum penalty under penalty mechanism.

### 3.2 Percentages

The second statistical analysis shows the percentages of hospitals that are either receive a penalty, incentive, or neither for each peer group under each mechanism. The results of these percentages are shown in Figure 3.

Between 73-89% of hospitals are penalized under the current HRRP policy. Moving to the hybrid policy, roughly 43-51% of hospitals would receive a penalty. Interestingly, under the hybrid mechanism, the penalty/incentive split is nearly even at 50-50. The largest disparity occurs for the first peer group with 43% penalized and 57% incentivized. Moving into the incentive only mechanism would mean that roughly 93-96% of hospitals in each peer group would receive an incentive, leaving only a small percentage (less than 7%) of hospitals at a neutral position.

Giving the bonus to hospitals can be a decent way to inspire the hospitals to have better performance. The 95% confidence interval of difference between current penalty and hybrid mechanisms shows how much the hybrid mechanism can be better than penalty mechanism. This 95% confidence interval is equal to $(0.00628, 0.00681)$. Hence, hospitals can have an improvement in this interval when they are evaluated under the hybrid mechanism instead of the current penalty mechanism.

## 4. Conclusion

In this paper, we propose two alternative HRRP mechanism designs to the current HRRP penalty mechanism. The mathematical formulas for the newly proposed incentive factor and hybrid factor were presented. We presented a stastical analysis to compare the distribution and percentages of hospitals receiving penalties, incentives or neither by peer group classification. The statistical results also reveal a few preliminary observations. First, a few hospitals (less than 4% in each peer group) receive the maximum penalty for FY 2018. Based on distribution of hospitals, more than

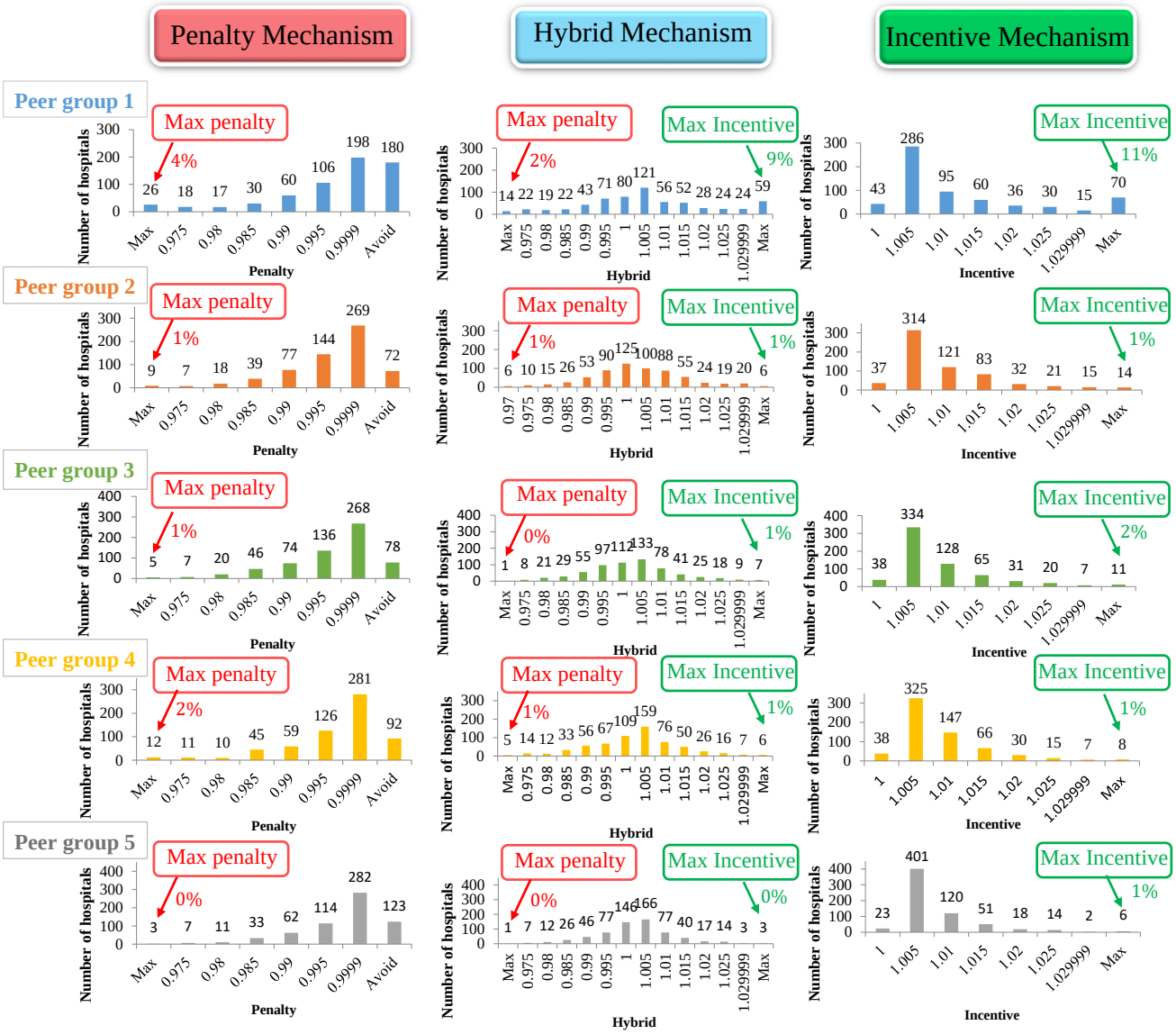


Figure 2: Number of hospitals receiving penalties and/or incentives by peer group under penalty, incentive and hybrid mechanisms

93% of hospitals in each peer group are eligible to receive incentive under incentive mechanism. Second, a reduction between 30-42% of penalized hospitals across all peer groups are available by moving to the hybrid mechanism. Our next steps are to develop an estimate of the financial impact of the shift from the current design to an incentive or hybrid HRRP design. Furthermore, we plan to analyze mechanisms based on hospital characteristics (e.g., hospital type, % of Medicaid patients, hospital size, etc.) to determine if certain hospital types are worse-off under any of the proposed mechanism designs.

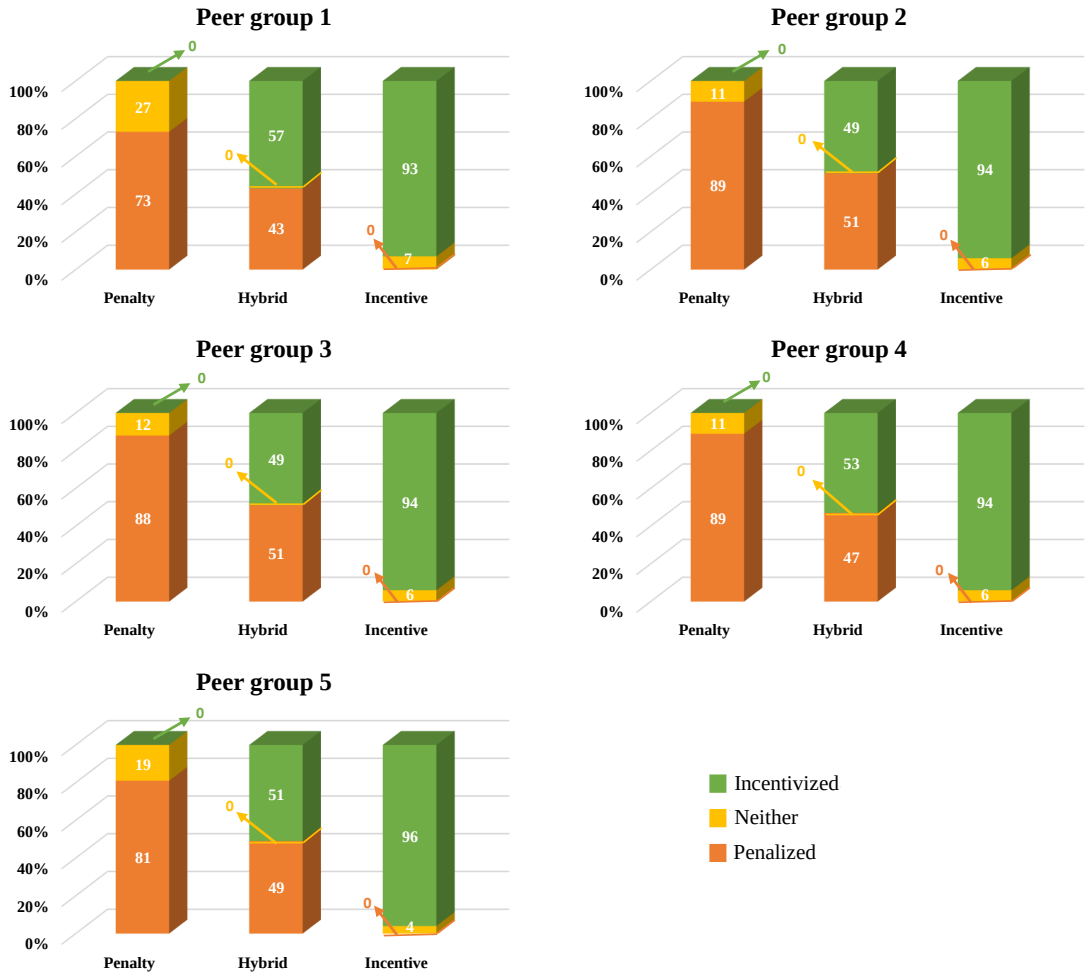


Figure 3: Percentages of penalized / non penalized hospitals and incentivized / non incentivized hospitals for each peer group under penalty, incentive and hybrid mechanisms

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