

# Out-of-Pocket Spending for Cardiac Rehabilitation and Adherence Among US Adults

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**C**ardiovascular disease (CVD) remains the leading cause of morbidity and mortality in the US.<sup>1,2</sup> Although great advancements have been made in treating CVD, there is a growing emphasis on promoting long-term health and preventing readmission following a cardiac event through cardiac rehabilitation (CR).<sup>3</sup> CR is a comprehensive, multidisciplinary program designed to optimize cardiovascular-related health for those with CVD and typically entails 36 1-hour sessions of supervised exercise-based therapy and healthy lifestyle education.<sup>4</sup> Recent meta-analyses have demonstrated CR's proven role in decreasing cardiovascular-related mortality by 25% and hospital readmissions by 18%, driving its endorsement as a class 1a recommendation as standard of care following an acute myocardial infarction (AMI) or coronary artery bypass grafting (CABG).<sup>5,6</sup> Additionally, a dose-dependent relationship exists between the number of CR sessions attended and improved cardiovascular outcomes, underscoring the importance of completing the program to fully realize its health benefits.<sup>7-9</sup>

Despite CR's effectiveness, it remains underutilized, with only approximately one-third of qualified participants attending CR and evidence of poor adherence once enrolled.<sup>10-12</sup> Although there are several well-studied barriers to CR adherence, out-of-pocket (OOP) costs may serve as an important barrier, particularly for commercial beneficiaries who may face higher co-pays per CR session compared with the average \$23 paid by traditional Medicare fee-for-service participants.<sup>13-18</sup> Because CR is billed per session, patient spending may increase with more sessions attended, potentially deterring those with OOP costs from completing the program. Therefore, it is imperative that we better understand how patients' OOP spending is related to CR attendance to inform payment reform, reduce CR costs, and promote adherence. In this context, we used a Merative (formerly IBM) MarketScan database to obtain claims data of commercially insured beneficiaries and evaluated the association between the OOP spending for patients' first CR session and CR adherence.

## ABSTRACT

**OBJECTIVES:** Although cardiac rehabilitation (CR) improves cardiovascular outcomes, adherence remains low. Higher patient-incurred out-of-pocket (OOP) spending may be a barrier to CR adherence. We evaluated the association between OOP spending for the first CR session and adherence.

**STUDY DESIGN:** Retrospective analysis.

**METHODS:** Commercial and Medicare supplemental beneficiaries with a CR-qualifying event between 2016 and 2020 who attended at least 1 CR session within 6 months of discharge were identified in the MarketScan Commercial Database. OOP spending for the first session was categorized as zero or into 1 of 3 increasing tertiles of OOP spending. Poisson regression was used to determine the association between OOP-spending tertile and CR adherence, defined as the number of CR sessions attended within 6 months of discharge.

**RESULTS:** A total of 43,992 beneficiaries attended at least 1 CR session. Of these, 35,883 (81.6%) paid \$0, 2702 (6.1%) paid \$0.01 to \$25.39, 2704 (6.1%) paid \$25.40 to \$82.41, and 2703 (6.1%) paid at least \$82.42 for the first session, constituting the first, second, and third OOP-spending tertiles, respectively. Compared with the zero-OOP cohort, the first-tertile cohort attended 13.5% (95% CI, 1.4%-27.1%;  $P = .028$ ) more CR sessions and the second- and third-tertile cohorts attended 11.9% (95% CI, -16.4% to -7.1%;  $P < .001$ ) and 30.9% (95% CI, -40.8% to -19.4%;  $P < .001$ ) fewer CR sessions on average, respectively. For every additional \$10 spent OOP on the first CR session, patients attended 0.41 fewer sessions on average (95% CI, -0.65 to -0.17;  $P < .001$ ).

**CONCLUSION:** Among patients with OOP spending, higher spending was associated with lower CR adherence, dose dependently. Reducing OOP costs for CR may improve adherence for beneficiaries with cost sharing.

*Am J Manag Care.* 2024;30(12):651-657. doi:10.37765/ajmc.2024.89637

## TAKEAWAY POINTS

Although cardiac rehabilitation (CR) improves cardiovascular outcomes, CR adherence remains poor. Patient-incurred out-of-pocket (OOP) spending may be an important barrier to CR adherence.

- ▶ Although most beneficiaries had zero OOP costs for the first CR session, among those with cost sharing, higher OOP spending was associated with attending fewer CR sessions and lower odds of completing more than 24 sessions, dose dependently, after multivariable adjustment.
- ▶ Reducing OOP costs may improve CR adherence and clinical outcomes among those with cost sharing for CR.
- ▶ Because CR is a cost-effective intervention, insurance companies should reduce OOP costs for CR to improve the value of cardiovascular care.

## CR Sessions

The total number of CR sessions completed by each beneficiary was compared across OOP-spending cohorts to assess the relationship between OOP spending for the first CR session and CR adherence. The primary outcome of interest was the total number of CR sessions attended within 6 months of discharge. The secondary outcome of interest was the odds of attending more than 24 sessions, given a potential plateau in the health benefits after attending more than 24 sessions.<sup>9</sup>

## METHODS

## Data Source and Variables

We used the MarketScan Commercial Database, which contains deidentified patient-level health data linked to inpatient and outpatient claims of employer-based commercially insured and Medicare supplemental beneficiaries.<sup>19</sup> This database also discloses OOP charges for each CR claim, patient age, sex, date of admission/discharge for the qualifying event and CR sessions, and geographic region.<sup>19</sup> This study was approved by the University of Michigan Institutional Review Board (HUM00211102) and adhered to the Strengthening of the Reporting of Observational Studies in Epidemiology guidelines.

## Study Cohort

Using claims from January 1, 2016, to December 31, 2020, we identified commercial and Medicare supplemental beneficiaries aged 18 to 75 years who experienced at least 1 CR-qualifying event: AMI, CABG, percutaneous coronary intervention, or heart valve replacement or repair. Qualifying events were identified via *International Statistical Classification of Diseases, Tenth Revision (ICD-10)* diagnostic or procedure codes and *Current Procedural Terminology* codes as described elsewhere (eAppendix Methods [eAppendix available at [ajmc.com](https://ajmc.com)]).<sup>12</sup> CR sessions attended within 6 months of discharge were identified within outpatient facility and professional claims using Healthcare Common Procedure Coding System code 93797, 93798, G0422, or G0423 and revenue center code 0943.<sup>20</sup> We included those who were continuously enrolled in their insurance policies 6 months after the event and who attended at least 1 CR session within 6 months of discharge from the qualifying event. Patients admitted for more than 30 days were excluded to ensure beneficiaries were reasonable CR candidates (eAppendix Figure 1).<sup>7</sup>

## OOP Spending

For the first CR session, we obtained the total beneficiary OOP spending by summing the co-pay, coinsurance, and deductible amounts for that session. We categorized OOP spending for the first CR session into those with zero OOP spending and tertiles above zero to obtain 4 OOP-spending cohorts that comprised the covariate of interest.

## Covariates

To account for comorbidities that may confound CR adherence, we used secondary *ICD-10* diagnosis codes from the index admission claim and calculated each patient's Elixhauser Comorbidity Index (ECI) score.<sup>21,22</sup> Our regression models also adjusted for age, sex, qualifying event, days elapsed between the qualifying event discharge date and first session, insurance type (ie, Medicare supplemental vs commercial), geographic region, and calendar year and quarter of the qualifying event. The yearly quarter was included to account for seasonal variations in CR attendance and patients' remaining deductibles when approaching the end of the year.

## Statistical Analysis

Differences between baseline characteristics and total CR sessions attended were compared using  $\chi^2$  test and 1-way analysis of variance for categorical and continuous variables, respectively. The Kruskal-Wallis test was used to compare the medians of the total CR sessions attended and days elapsed from the date of discharge to the first session between OOP-spending cohorts. For the primary outcome, Poisson regression was used to estimate the mean number of CR sessions attended as a function of the OOP cohort, controlling for our covariates. The incident rate ratio for the OOP-spending cohort covariate was converted to relative rate change to intuitively represent the association between OOP spending and CR adherence.

Several sensitivity analyses were performed. Multivariable logistic regression was used for the secondary outcome to compare the probability of completing more than 24 sessions across OOP-spending cohorts and of attending a second CR session to account for the impact delays in CR enrollment may have on the effective time left to complete further sessions. We additionally performed a subgroup analysis restricted to patients who attended the first session in January and February to assess the impact of deductibles resetting at the beginning of the calendar year. The zero-OOP cohort served as the reference group for all regression models.

Lastly, OOP spending was modeled as a continuous variable to estimate the change in the mean number of CR sessions attended and likelihood of attending more than 24 sessions for every \$10 increase in OOP spending for the first session. We performed a robustness check with squared and cubic terms of the OOP-spending

**TABLE 1.** Baseline Characteristics of Patient Cohorts Stratified by OOP Spending for the First Cardiac Rehabilitation Session

Characteristic	Zero OOP-spending cohort	OOP-spending tertile 1 (\$0.01-\$25.39)	OOP-spending tertile 2 (\$25.40-\$82.41)	OOP-spending tertile 3 (≥\$82.42)	P
n	35,883	2702	2704	2703	
Age of patient in years, mean (SD)	57.6 (8.4)	58.0 (8.9)	57.0 (8.2)	56.3 (8.0)	< .001
Sex of patient, n (%)					.87
Male	26,748 (74.5%)	2000 (74.0%)	2023 (74.8%)	2026 (75.0%)	
Female	9135 (25.5%)	702 (26.0%)	681 (25.2%)	677 (25.0%)	
Prior AMI, n (%)	16,564 (46.2%)	1363 (50.4%)	1407 (52.0%)	1316 (48.7%)	< .001
Prior CABG, n (%)	10,666 (29.7%)	655 (24.2%)	694 (25.7%)	778 (28.8%)	< .001
Prior valve replacement or repair, n (%)	5522 (15.4%)	345 (12.8%)	315 (11.6%)	372 (13.8%)	< .001
Prior PCI, n (%)	17,977 (50.1%)	1484 (54.9%)	1449 (53.6%)	1371 (50.7%)	< .001
Elixhauser Comorbidity Index score, mean (SD)	1.5 (1.3)	1.4 (1.3)	1.4 (1.3)	1.5 (1.3)	< .001
Insurance type, n (%)					< .001
Commercial	30,422 (84.8%)	2145 (79.4%)	2342 (86.6%)	2464 (91.2%)	
Medicare supplemental	5461 (15.2%)	557 (20.6%)	362 (13.4%)	239 (8.8%)	
Region					
Northeast	5210 (14.5%)	576 (21.3%)	471 (17.4%)	419 (15.5%)	< .001
North Central	11,909 (33.2%)	765 (28.3%)	651 (24.1%)	579 (21.4%)	
South	15,311 (42.7%)	1104 (40.9%)	1222 (45.2%)	1463 (54.1%)	
West	3392 (9.5%)	252 (9.3%)	355 (13.1%)	240 (8.9%)	
Unknown	61 (0.2%)	5 (0.2%)	5 (0.2%)	2 (0.1%)	
Year of discharge from qualifying event, n (%)					< .001
2016	10,399 (29.0%)	781 (28.9%)	802 (29.7%)	647 (23.9%)	
2017	8731 (24.3%)	693 (25.6%)	638 (23.6%)	741 (27.4%)	
2018	7559 (21.1%)	599 (22.2%)	540 (20.0%)	668 (24.7%)	
2019	7100 (19.8%)	487 (18.0%)	561 (20.7%)	515 (19.1%)	
2020	2094 (5.8%)	142 (5.3%)	163 (6.0%)	132 (4.9%)	

AMI, acute myocardial infarction; CABG, coronary artery bypass grafting; OOP, out-of-pocket; PCI, percutaneous coronary intervention.

variable to allow for a nonlinear relationship between OOP spending and predicted number of CR sessions attended.

All analyses were conducted using Stata 15 MP (StataCorp LLC). A 2-sided P value of less than .05 was considered statistically significant.

## RESULTS

### Baseline Characteristics

Among the 43,992 beneficiaries who attended at least 1 CR session within 6 months of their qualifying event discharge date (33.6% of the CR-eligible cohort), the mean (SD) participant age was 57.4 (8.4) years, 32,797 (74.6%) were men, and 37,373 (85.0%) were commercially insured (eAppendix Table 1 and eAppendix Figure 1). Compared with nonparticipants, CR participants were more likely to be men and had a higher mean ECI score (1.12 vs 1.52;  $P < .001$ ) (eAppendix Table 1).

### OOP Spending and CR Adherence

Of the beneficiaries who attended CR, 35,883 (81.6%) had zero OOP spending for the first CR session. For those with OOP spending,

2702 (6.1%) paid between \$0.01 and \$25.39, 2704 (6.1%) paid between \$25.40 and \$82.41, and 2703 (6.1%) paid \$82.42 or more for the first CR session, constituting the first, second, and third OOP-spending tertiles, respectively (Table 1). The mean (SD) OOP spending for the first session for commercial and Medicare supplemental beneficiaries with cost sharing was \$81.97 (\$77.75) (range, \$0.01-\$562.15) and \$43.94 (\$39.88) (range, \$0.01-\$238.12), respectively ( $P < .001$ ). The zero-OOP and third-tertile cohorts had the highest mean ECI score, and the third-tertile cohort had the greatest delay in attending the first CR session (Tables 1 and 2). The unadjusted mean and median number of CR sessions attended were highest in the first-tertile cohort and progressively decreased across the second and third OOP tertiles (Table 2).

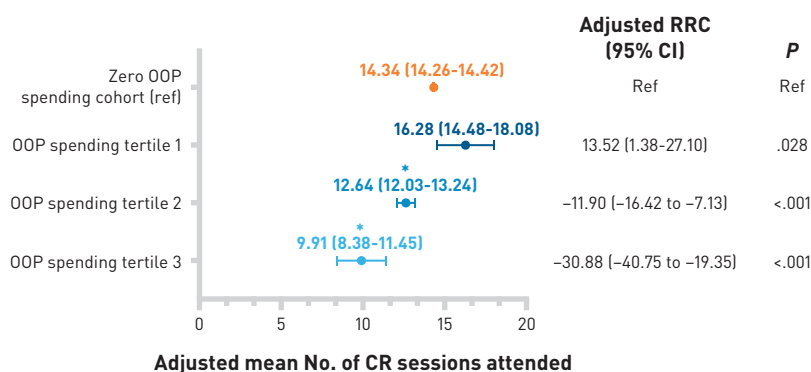
For the primary outcome of total number of CR sessions attended within 6 months of discharge, compared with the zero-OOP cohort, the second- and third-tertile cohorts attended 11.9% (95% CI, -16.4% to -7.1%;  $P < .001$ ) and 30.9% (95% CI, -40.8% to -19.4%;  $P < .001$ ) fewer CR sessions on average, respectively, and the first-tertile cohort attended 13.5% (95% CI, 1.4%-27.1%;  $P = .028$ ) more CR sessions after

**TABLE 2.** Unadjusted Descriptive Statistics Describing the Mean, Median, and Proportion of CR Sessions Attended Across OOP-Spending Cohorts

CR sessions attended	Zero OOP-spending cohort (n = 35,883)	OOP-spending tertile 1 (\$0.01-\$25.39) (n = 2702)	OOP-spending tertile 2 (\$25.40-\$82.41) (n = 2704)	OOP-spending tertile 3 (≥ \$82.42) (n = 2703)	P
Days from qualifying event to first CR session, mean (SD)	43.37 (34.08)	44.63 (37.03)	45.05 (37.24)	55.03 (41.7)	< .001
Days from qualifying event to first CR session, median (IQR)	34 (20-55)	34 (19-58)	33 (19-59)	43 (25-72)	< .001
Mean (SD) number of CR sessions	14.45 (12.40)	16.39 (12.25)	12.37 (11.47)	9.06 (10.15)	< .0001
Median (IQR) number of CR sessions	10 (3-25)	14 (5-27)	7 (3-20)	4 (2-13)	< .0001
> 18 CR sessions, n (%)	12,455 (34.7%)	1107 (41.0%)	749 (27.7%)	475 (17.6%)	< .0001
> 24 CR sessions, n (%)	9034 (25.2%)	775 (28.7%)	494 (18.3%)	293 (10.8%)	< .0001

CR, cardiac rehabilitation; OOP, out-of-pocket.

**FIGURE 1.** Adjusted Mean Number of CR Sessions Attended Across OOP-Spending Cohorts\*



CR, cardiac rehabilitation; OOP, out-of-pocket; ref, reference; RRC, relative rate change.

\*The adjusted RRC demonstrates the percentage change in the predicted mean number of CR sessions attended between each nonzero cohort and the zero OOP-spending cohort (reference group) after multivariable adjustment. Numbers above the data points represent the mean number of CR sessions attended, followed by the 95% CI. Asterisks represent a statistically significant difference ( $P < .05$ ) in the adjusted mean number of CR sessions attended between the OOP tertile and reference group.

after multivariable adjustment; there was no significant difference in the likelihood of attending more than 24 sessions between the first-tertile and zero-OOP cohorts (aOR, 1.21; 95% CI, 0.91-1.61;  $P = .190$ ) (Figure 3). For every additional \$10 spent OOP on the first CR session, the probability of attending more than 24 sessions decreased by 0.95% (95% CI, -1.37% to -0.54%;  $P < .001$ ).

Of the patients who had their first CR session in January or February, 3732 (53.6%) had zero OOP costs for the first session. The second-tertile and third-tertile cohorts attended 14.6% (95% CI, -23.0% to -5.2%) and 32.2% (95% CI, -43.0% to -19.4%) fewer mean sessions, respectively, compared with the zero-OOP cohort, but there was no significant difference in the adjusted mean number of sessions attended between the first-tertile and zero-OOP cohorts (6.26%; 95% CI, -0.18% to 13.12%) (eAppendix Figure 5).

multivariable adjustment (Figure 1). Spending in the third OOP tertile was the strongest negative predictor of CR adherence in our model (eAppendix Table 2). Compared with the zero-OOP cohort, the first-tertile cohort was also more likely to attend a second CR session (adjusted OR [aOR], 1.21; 95% CI, 1.09-1.33;  $P = .007$ ), whereas the third-tertile cohort was significantly less likely to do so (aOR, 0.72; 95% CI, 0.60-0.87;  $P < .001$ ) (eAppendix Figure 2). For every additional \$10 spent OOP on the first CR session, the mean number of total sessions attended decreased by 0.41 (95% CI, -0.65 to -0.17;  $P < .001$ ) (Figure 2), with this inverse relationship persisting after transforming the OOP-spending variable into squared and cubic terms (eAppendix Figures 3 and 4).

For the secondary outcome, the second-tertile (aOR, 0.70; 95% CI, 0.60-0.82;  $P < .001$ ) and third-tertile (aOR, 0.44; 95% CI, 0.36-0.53;  $P < .001$ ) cohorts were significantly less likely to attend more than 24 sessions compared with the zero-OOP cohort

## DISCUSSION

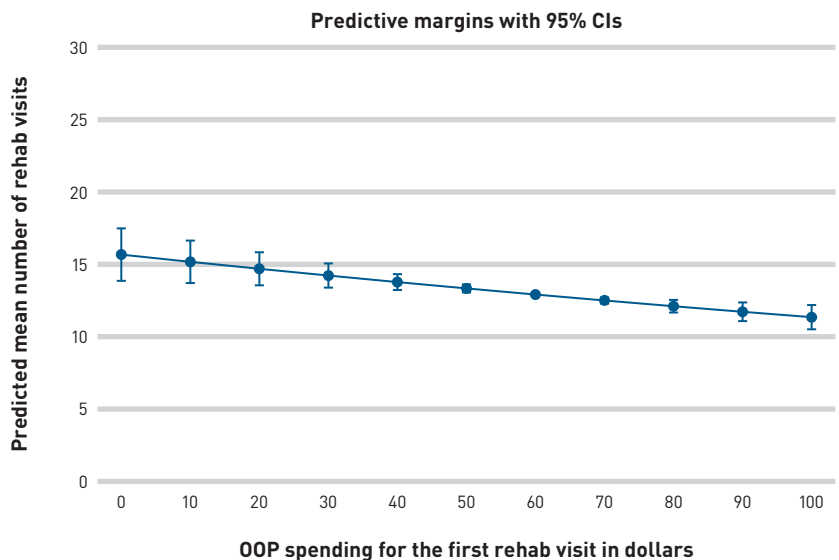
In this retrospective study involving a large cohort of commercial and Medicare supplemental beneficiaries who attended at least 1 CR session, we observed 3 key findings. First, more than 80% of our cohort had no OOP spending for the first CR session. Second, those in the first OOP-spending tertile attended more CR sessions than the zero-OOP cohort. Third, among the remaining CR participants with cost sharing, greater OOP spending for the first session was associated with lower CR adherence in a dose-dependent manner, suggesting that lower OOP costs are associated with increased CR adherence among beneficiaries with cost sharing for CR.

Our findings are consistent with those of a smaller study of 603 patients by Farah et al, which demonstrated that greater cost sharing was associated with lower CR attendance and found a greater effect of 1.5 fewer sessions attended for every \$10 increase in total OOP

spending for CR.<sup>23</sup> However, our study is the first to showcase similar findings in a nationally representative commercially insured population that may be subject to more variable OOP costs for CR compared with traditional Medicare patients.<sup>24</sup> Indeed, of those with cost sharing for CR, we found commercial beneficiaries spent significantly more, on average, and had more variable OOP spending for the first session than their Medicare counterparts, which is concordant with findings of prior studies comparing cost-sharing patterns between commercial and Medicare beneficiaries for outpatient services.<sup>13-15,24</sup> Overall, our study provides important and timely insight on the relationship between cost sharing and CR adherence, a topic of interest among investigators seeking to promote CR participation and equitable delivery of CR services.<sup>17,25,26</sup>

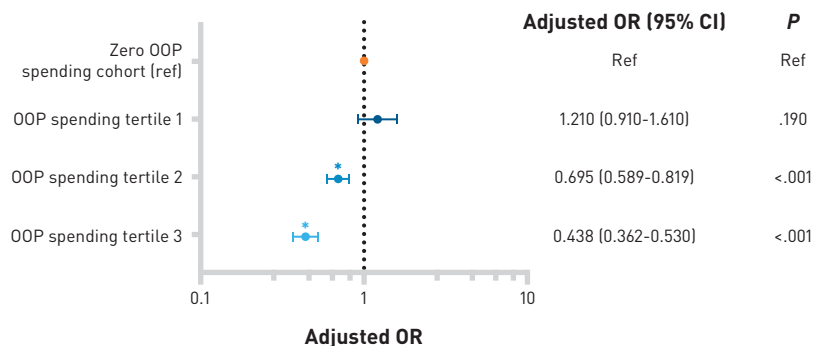
Importantly, we found that most patients had zero cost sharing for the first CR session, suggesting that OOP costs may not be a barrier to CR adherence for many beneficiaries. Nonmonetary factors (eg, time, travel distance) may be more important barriers. However, our findings may be explained by differences in benefit design and health care spending between the zero- and nonzero-OOP groups. The zero-OOP cohort may have been less healthy and utilized more health care, consequently meeting their deductible prior to CR enrollment. Similarly, the 63% of patients in the Farah et al study with zero cost sharing were older with lower functional capacity.<sup>23</sup> In our study, most beneficiaries' OOP spending may have been clustered around the CR-qualifying hospitalization, increasing the likelihood of meeting their deductible before enrollment, as demonstrated in a previous study evaluating clustering in OOP spending for hospitalized commercial beneficiaries.<sup>27</sup> Indeed, the proportion of beneficiaries in our study with zero cost sharing decreased to 53% for those who attended the first session after deductibles reset, suggesting our results were driven in part by the deductible being met prior to enrollment. However, because most patients still had zero cost sharing, employer-based policies may cover CR as an essential health benefit, with a minority of policies having deductibles that exceed the qualifying-event cost or that charge coinsurance for CR.<sup>28</sup> Without further information on patients' benefit design, we cannot make conclusions on what drove this finding. Nevertheless, our study findings demonstrated

**FIGURE 2.** Change in the Predicted Mean Number of CR Sessions Attended for Every \$10 Increase in OOP Spending for the First CR Session<sup>a</sup>



CR, cardiac rehabilitation; OOP, out-of-pocket.  
<sup>a</sup>Vertical bars represent the 95% CI.

**FIGURE 3.** Adjusted ORs of Attending More Than 24 CR Sessions Across OOP-Spending Cohorts<sup>a</sup>



CR, cardiac rehabilitation; OOP, out-of-pocket; ref, reference.

<sup>a</sup>The zero OOP-spending cohort is the reference group. Asterisks represent a statistically significant difference ( $P < .05$ ) in the adjusted OR of attending more than 24 CR sessions between the OOP tertile and reference group.

a consistent inverse relationship between adherence and OOP spending for the first CR session among those with cost sharing. Therefore, reducing OOP costs for CR may be an effective strategy to promote adherence in a subpopulation with cost sharing for CR.

Notably, patients in the first OOP-spending tertile attended more sessions than the zero-OOP group. Although we cannot definitively determine why this relationship exists, we suspect that because the zero-OOP cohort comprised the majority of our sample, it is likely

a more heterogeneous population with clinical and demographic confounders that we could not account for. These patients had a higher comorbidity index score, which may have prevented them from attending further CR sessions.<sup>18,29</sup> Although we controlled for ECI score, we could not assess functional capacity or disease severity. Moreover, our ECI score was derived from the index hospitalization claim rather than all claims from the previous year, limiting its utility. The zero-OOP cohort also may have had less reliable transportation, lived further from the CR facility, or been composed of a higher proportion of patients of lower socioeconomic status or minority groups with historically lower CR adherence rates.<sup>11,23,29-33</sup> Because we used claims data, we could not assess granular patient-level variables that may account for this discrepancy. OOP costs are one of many factors associated with CR adherence and likely impact CR participation in subpopulations differently. Future research should evaluate socioeconomic and demographic factors that impact CR adherence in commercial beneficiaries.

Although we evaluated OOP spending for the first CR session, we cannot assume a temporal relationship between the cost for the first session and subsequent adherence because patients may only be billed after multiple sessions. However, because the per-session OOP fee is based on a reimbursement amount set by the insurance payer and we were evaluating the same outpatient service, the OOP cost may vary minimally between CR sessions.<sup>15</sup> Higher OOP spending for the first session may therefore translate to proportionally higher spending for multiple sessions, which may disincentivize participation and account for our findings. A bundled payment model in which patients are charged a onetime fee for CR may improve adherence by mitigating higher anticipated costs when billing for sessions recurrently.<sup>34,35</sup> Nevertheless, there is likely substantial variability in billing practices, and we did not know the frequency or timing of beneficiaries' CR charges. The impact of specific billing practices on CR adherence should be explored in future studies.

In this study, we demonstrate the paradox of cost sharing and its association with CR adherence and timing of enrollment. Although cost sharing is meant to disincentivize unnecessary health care consumption, it also results in the underutilization of cost-effective outpatient interventions.<sup>36,37</sup> Increased co-pays for ambulatory care have been shown to result in 19.8 fewer appointments attended per year, which may pertain to CR as it entails repetitive outpatient sessions.<sup>37</sup> Those in the highest OOP-spending tertile also had the greatest delay in enrollment and were less likely to attend a second session, suggesting their lower adherence was unlikely due to having less time to complete more sessions. Because delays in enrollment are related to lower CR participation and adherence, reducing cost sharing may improve these metrics by mitigating delays in enrollment itself.<sup>38,39</sup> However, we do not know when patients were informed of their projected costs and how that impacted their decision to attend CR.

Our study supports quality improvement initiatives outlined in the Million Hearts Cardiac Rehabilitation Change Package, a collaboration

between the CDC and the American Association of Cardiovascular and Pulmonary Rehabilitation, targeting cost-sharing barriers for CR services to promote CR adherence.<sup>40</sup> For example, by developing philanthropic financial assistance programs, hospitals can help offset OOP expenses for CR for those who are underinsured, which may improve CR participation for patients with less comprehensive health plans and reduce disparities in cardiovascular care.<sup>40,41</sup> Institutions may also proactively connect patients with their billing department to discuss CR costs and formulate affordable payment plans for those unable to pay their co-pays in full.<sup>40</sup> Although high-value care is being incentivized through value-based physician reimbursement models, future payment-reform policy should focus on developing payment models that reduce patient-incurred costs for cost-effective interventions such as CR.<sup>41-45</sup>

### Limitations

Our study has multiple limitations. First, we did not include patients who did not attend CR and could not identify their OOP spending because we could not access their benefit design. We were therefore unable to assess the effect of cost sharing or the expected cost of attending CR among those who never attended. Additionally, we did not have information on patients' remaining deductible, coverage benefits, frequency of billing, or timing of when they were informed of their projected OOP costs, which may have influenced our findings. We also used claims data, so we were unable to evaluate potential socioeconomic and demographic confounders. Lastly, because the MarketScan Commercial Database only contains beneficiaries with employer-based policies, we cannot generalize these findings to non-employer-based beneficiaries with potentially different OOP liabilities for CR.

## CONCLUSIONS

Among commercial and Medicare supplemental beneficiaries insured by an employer, most who attended CR had zero OOP spending for their first session, suggesting that OOP costs are not a barrier to CR adherence for most employer-based beneficiaries. However, for the minority of beneficiaries with cost sharing, higher spending for the first session was associated with lower CR adherence in a dose-dependent manner. Because CR is a cost-effective intervention that significantly improves cardiovascular-related morbidity and mortality and the value of cardiovascular care, insurance companies should consider policies that reduce patient-incurred OOP spending for those with cost sharing for CR to ensure CR adherence.<sup>37,45</sup> ■

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**Source of Funding:** None.

**Author Disclosures:** The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

**Authorship Information:** Concept and design (AIM, MPT, SK, DS); acquisition of data (DS); analysis and interpretation of data (AIM, UN, MPT, DS); drafting of

the manuscript (AIM, SK, DS); critical revision of the manuscript for important intellectual content (AIM, UN, MPT, SK, DS); statistical analysis (UN); administrative, technical, or logistic support (AIM); and supervision (DS).

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## **eAppendix**

**eAppendix Methods: Diagnostic and procedure codes used to identify CR qualifying events.**

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**eAppendix Figure 5: Adjusted mean number of CR sessions attended across OOP spending cohorts, restricted to those who attended the first session in January and February of the calendar year.**



## **eAppendix Methods: Diagnostic and procedure codes used to identify CR qualifying events**

### Acute Myocardial Infarction:

**ICD10:** I21.0, I21.01, I21.02, I21.09, I21.1, I21.11, I21.19, I21.2, I21.21, I21.29, I21.3, I21.4, I21.9, I21.A1†, I21.A9†, I22.0, I22.1, I22.2, I22.8, I22.9

### Coronary Artery Bypass Graft Surgery:

**ICD10:** 0210, 0211, 0212, 0213

**CPT:** 33510, 33511, 33512, 33513, 33514, 33516, 33517, 33518, 33519, 33521, 33522, 33523, 33530, 33533, 33534, 33535, 33536, 33572, 35600, S2205, S2206, S2207, S2208, S2209

### Valve Repair or Replacement:

**ICD10:** 027F, 027G, 027H, 027J, 02CF, 02CG, 02CH, 02CJ, 02NF, 02NG, 02NH, 02NJ, 02QF, 02QG, 02QH, 02QJ, 02RF, 02RG, 02RH, 02RJ, 02TH, 02VG, 02UF, 02UG, 02UH, 02UJ

**CPT:** 33361-33417, 33418-33430, 33460-33468, 33470-33478

### Percutaneous Coronary Intervention:

**ICD10:** 02703ZZ, 02704ZZ, 02713ZZ, 02714ZZ, 02723ZZ, 02724ZZ, 02733ZZ, 02734ZZ, 3E07017, 3E070PZ, 3E07317, 3E073PZ, 02700ZZ, 02710ZZ, 02720ZZ, 02730ZZ, 02C00ZZ, 02C10ZZ, 02C20ZZ, 02C30ZZ, 02C03ZZ, 02C04ZZ, 02C13ZZ, 02C14ZZ, 02C23ZZ, 02C24ZZ, 02C33ZZ, 02C34ZZ

**CPT:** 92920, 92921, 92924, 92925, 92928, 92929, 92933, 92934, 92937, 92938, 92941, 92943, 92944, 92973, 92974

† Effective October 1, 2017

**eAppendix Table 1: Baseline characteristics of CR participation groups**

	<b>Did not attend CR</b>	<b>Attended <math>\geq</math> 1 CR session</b>	<b>p-value</b>
<b>N</b>	87,054	43,992	
<b>Age of Patient, mean (SD)</b>	57.42 (8.85)	57.47 (8.44)	0.33
<b>Gender of Patient</b>			
Male	63,736 (73.2%)	32,797 (74.6%)	<0.001
Female	23,318 (26.8%)	11,195 (25.4%)	
<b>AMI</b>	34,995 (40.2%)	20,650 (46.9%)	<0.001
<b>CABG</b>	8,814 (10.1%)	12,793 (29.1%)	<0.001
<b>Valve Replacement or Repair</b>	6,809 (7.8%)	6,554 (14.9%)	<0.001
<b>PCI</b>	57,560 (66.1%)	22,281 (50.6%)	<0.001
<b>Elixhauser Comorbidity Count, mean (SD)</b>	1.12 (1.32)	1.52 (1.30)	<0.001
<b>Insurance Type</b>			<0.001
Commercial	72,664 (83.5%)	37,737 (85%)	
Medicare Supplemental	14,390 (16.5%)	6,619 (15%)	
<b>Region</b>			
Northeast	16,199 (18.6%)	6,676 (15.2%)	<0.001
Northcentral	17,825 (20.5%)	13904 (31.6%)	
South	43,959 (50.5%)	19,100 (43.4%)	
West	8,864 (10.2%)	4,239 (9.6%)	
Unknown	207 (0.2%)	73 (0.2%)	
<b>Year of discharge from qualifying event</b>			
2016	25,870 (29.7%)	12,629 (28.7%)	<0.001
2017	21,220 (24.4%)	10,803 (24.6%)	
2018	16,615 (19.1%)	9,366 (21.3%)	
2019	13,586 (15.6%)	8,663 (19.7%)	
2020	9,763 (11.2%)	2,531 (5.8%)	

<b>Number days from qualifying event to first cardiac rehab, mean (SD)</b>	N/A	44.27 (35.09)	N/A
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*AMI=acute myocardial infarction; CABG=coronary artery bypass grafting; PCI=percutaneous coronary intervention; SD=standard deviation; OOP=out-of-pocket*

**eAppendix Table 2: Adjusted outcomes analysis; independent predictors of mean number of cardiac rehabilitation sessions attended.**

<b>Covariate</b>	<b>Relative Rate Change (%)</b>	<b>95% Confidence Interval</b>	<b>p-value</b>
<b>OOP Cost Tertile</b>			
Zero OOP Spending (ref)			
OOP Spending Tertile 1	13.52	(1.38, 27.1)	0.028
OOP Spending Tertile 2	-11.9	(-16.42, -7.13)	<0.001
OOP Spending Tertile 3	-30.88	(-40.75, -19.35)	<0.001
<b>Baseline Characteristics</b>			
Age	0.83	(0.65, 1.01)	<0.001
Female gender	-4.35	(-6.84, -1.78)	0.001
Elixhauser Comorbidity Count	-2.93	(-6.06, 0.30)	0.075
Days elapsed until first session	-0.36	(-0.44, -0.28)	<.001
Insurance Type*	9.83	(-9.91, 33.89)	.354
<b>Qualifying event</b>			
AMI	14.02	(10.56, 17.58)	<.001
CABG	9.38	(7.58, 11.21)	<.001
PCI	-9.03	(-14.01, -3.77)	<.001
Valve Repair or Replacement	9.78	(9.04,10.52)	<.001
<b>Region</b>			
Northeast (ref)			
Northcentral	6.3	(5.95, 6.65)	<.001
South	-19.89	(-21.90, -17.83)	<.001
West	-2.84	(-4.54, -1.12)	.001
Unknown	10.6	(8.0, 13.26)	<.001
<b>Year</b>			

	2016 (ref)			
	2017	0.59	(-2.85, 4.16)	0.740
	2018	7.65	(0.25, 15.58)	0.042
	2019	8.93	(2.06, 16.27)	0.010
	2020	-16.66	(-23.88, -8.76)	<.001
<b>Yearly Quarter</b>				
	Quarter 1 (ref)			
	Quarter 2	1.26	(-1.78, 4.40)	0.421
	Quarter 3	-4.13	(-6.02, -2.20)	<.001
	Quarter 4	-5.31	(-6.11, -4.5)	<.001

*\*With commercial insurance as the reference insurance type.*

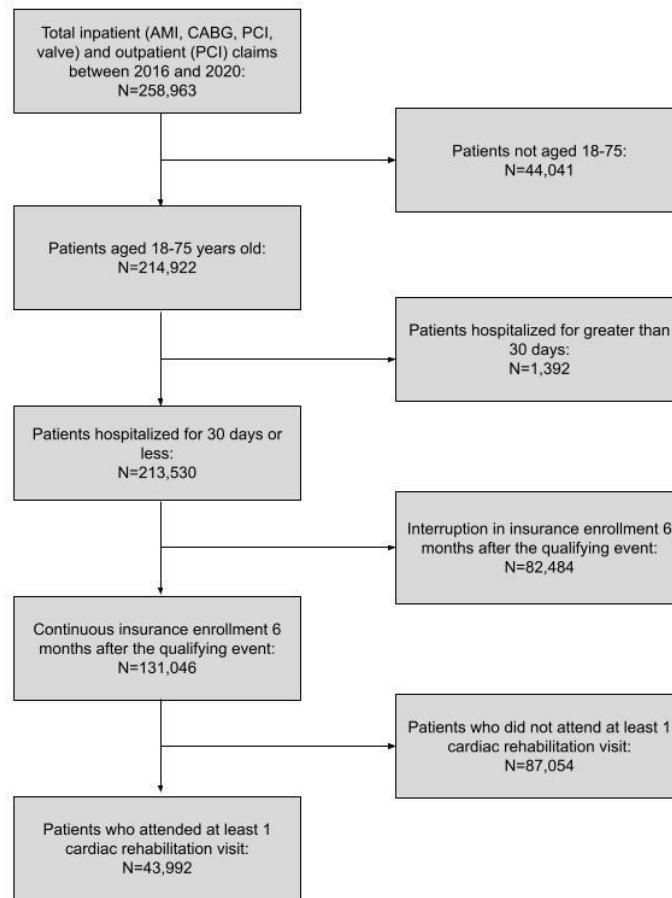
*AMI=acute myocardial infarction; CABG=coronary artery bypass grafting; PCI=percutaneous coronary intervention; Ref=reference; OOP=out-of-pocket*

**eAppendix Table 3: Adjusted probability of attending >24 CR sessions across OOP cost cohorts.**

<b>Covariate</b>	<b>Probability of attending &gt;24 CR sessions (%)</b>	<b>95% Confidence Interval (%)</b>	<b>p-value</b>
<b>Zero OOP Spending (ref) (\$0)</b>	24.86	(24.48, 25.23)	ref
<b>OOP Spending Tertile 1 (\$00.01-\$23.29)</b>	28.41	(23.24, 33.58)	0.202
<b>OOP Spending Tertile 2 (\$23.30-\$56.68)</b>	18.92	(16.64, 21.21)	<0.001
<b>OOP Spending Tertile 3 Tertile (<math>\geq</math>\$55.69)</b>	12.99	(10.95, 15.03)	<0.001

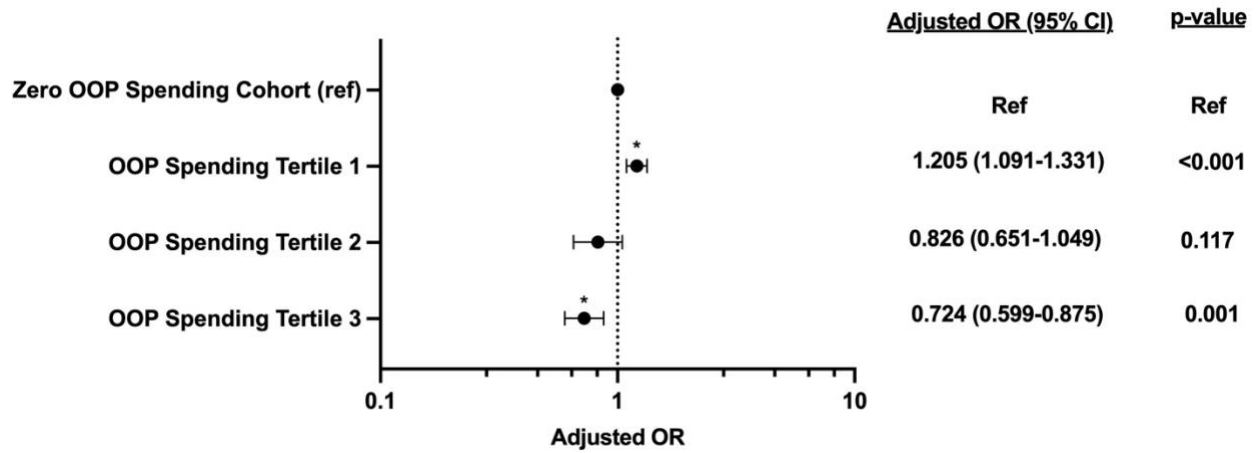
*CR=cardiac rehabilitation; OOP=out-of-pocket*

**eAppendix Figure 1: Study flow diagram.**



*AMI=acute myocardial infarction; CABG=coronary artery bypass grafting; PCI=percutaneous coronary intervention*

**eAppendix Figure 2: Adjusted odds ratio of attending a second CR session across OOP spending cohorts.**

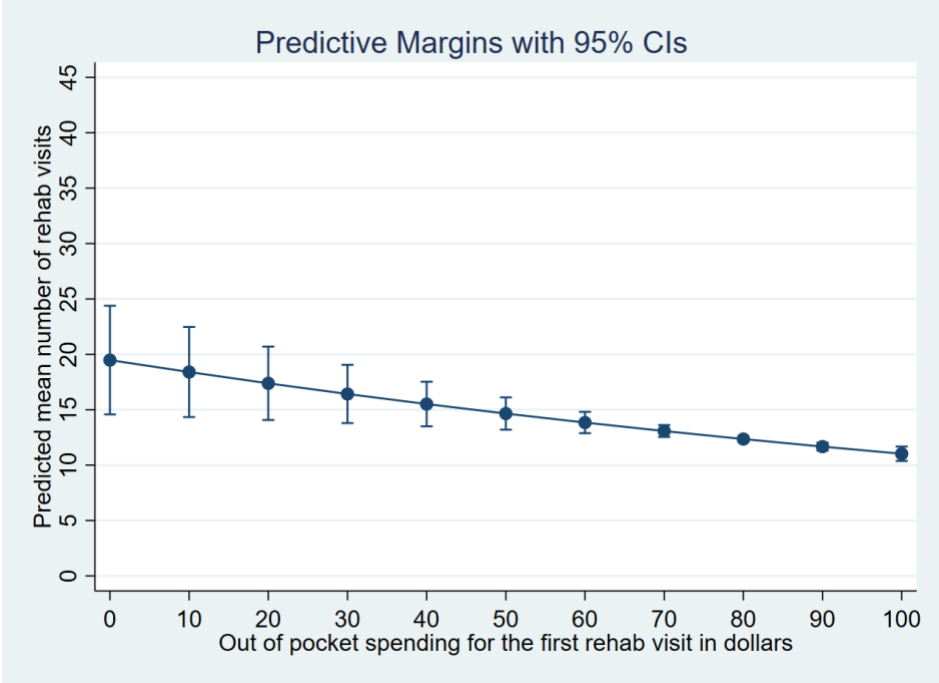


The zero out-of-pocket spending cohort is the reference group. Asterix represents a statistically significant difference in the adjusted OR of attending a second CR session compared to the reference group.

*OOP=*out-of-pocket; *OR=*odds ratio; *CR=*cardiac rehabilitation; *Ref=*reference;  
*CI=*confidence interval

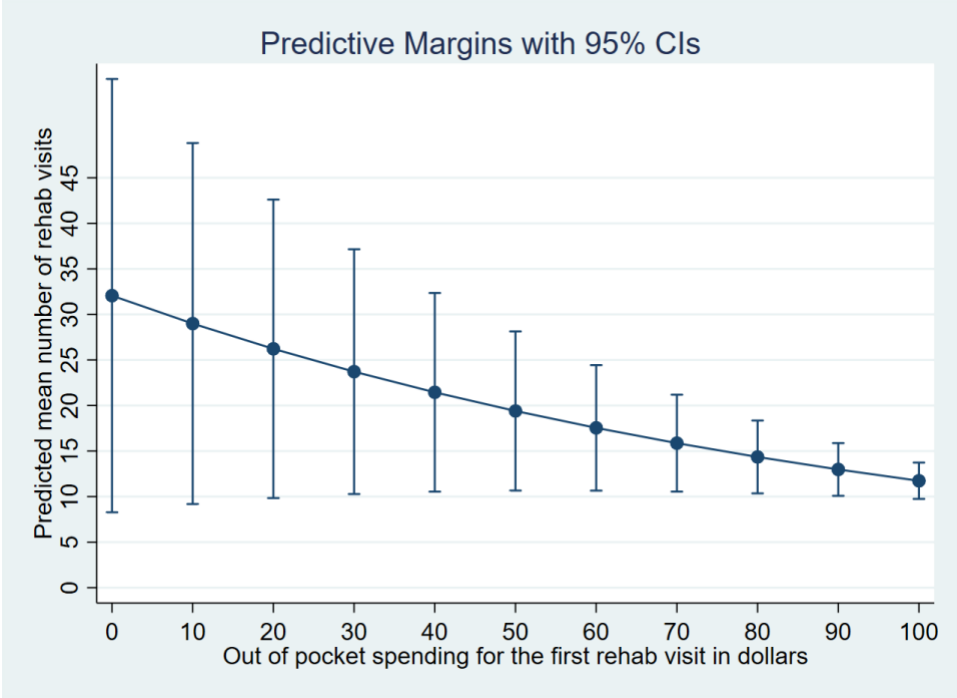


**eAppendix Figure 3: Adjusted predicted average number of cardiac rehabilitation sessions attended as a function of out-of-pocket spending for the first cardiac rehabilitation session with a squared out-of-pocket spending variable.**



Vertical bars represent the 95% confidence interval.  
*OOP=out-of-pocket; CR=cardiac rehabilitation*

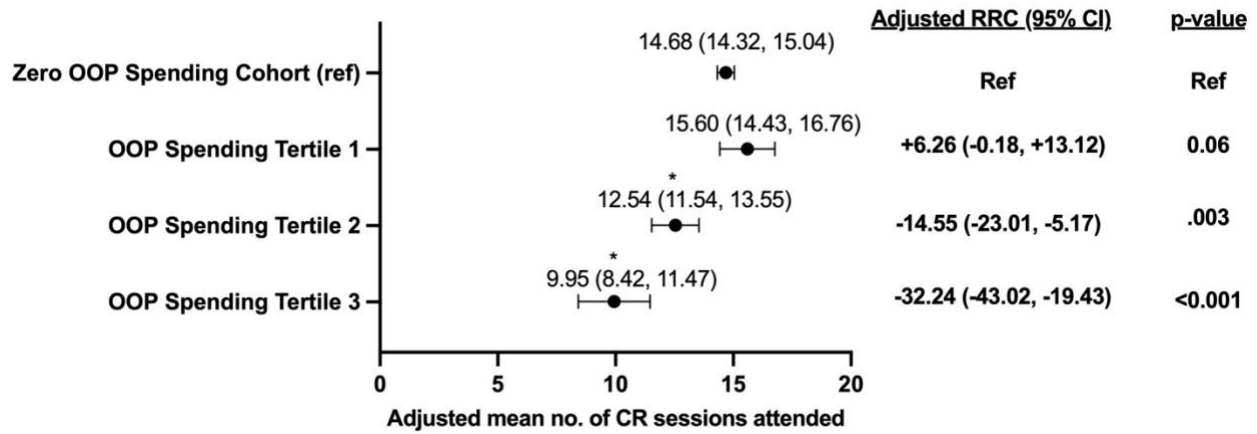
**eAppendix Figure 4: Robustness check of the adjusted predicted average number of cardiac rehabilitation sessions attended as a function of out-of-pocket spending for the first cardiac rehabilitation session with a cubed out-of-pocket spending variable.**



Vertical bars represent the 95% confidence interval.

*OOP=out-of-pocket; CR=cardiac rehabilitation*

**eAppendix Figure 5: Adjusted mean number of CR sessions attended across OOP spending cohorts of those who attended the first session in January and February of the calendar year.**



The adjusted relative rate change (RRC) demonstrates the percentage change in the predicted mean number of CR sessions attended between each non-zero and zero OOP spending cohort (reference group) after multivariable adjustment. Numbers above the data points represent the average number of CR sessions attended followed by the 95% CI. Asterisk represents a statistically significant difference in the adjusted mean number of CR sessions attended between the OOP tertile and reference group.

*OOP=*out-of-pocket; *RRC=*relative rate change; *CR=*cardiac rehabilitation; *Ref=*reference; *CI=*confidence interval