

# Additional testing of gaps in readmission measure score performance among selected subpopulations of interest defined by social risk factor (SRF) for the 2024 MUC submissions

## Overview

As part of the 2024 MUC submissions for the following six readmission measures:

- AMI Readmission (MUC2024-030)
- HF Readmission (MUC2024-032)
- Pneumonia Readmission (MUC2024-045)
- COPD Readmission (MUC2024-040)
- THA TKA Readmission (MUC2024-041)
- CABG Readmission (MUC2024-046)

We present additional testing results in Hospital-level, Risk-Standardized Readmission Rate (RSRR) measure score performance among selected subpopulations defined by social risk factors. We found that,

1. Patients with either of two social risk factors (high area deprivation index or dual eligibility) were at increased risk of unplanned readmissions, both before and after adjusting for other clinical risk factors in a multivariable model. However, model discrimination showed minimal change when adding the social risk factors to the risk model.
2. Additional testing was conducted to quantify the impact of social risk factors on measure scores. The testing results showed that measure scores estimated for hospitals with and without adjusting for either social risk factor were highly correlated, and differences in measure scores between the social-risk-factor unadjusted and adjusted measures were minimal.

Given these findings and the complex pathways that could explain any relationship between social risk and unplanned readmissions, we do not adjust for social risk variables in the measures.

## Introduction

CMS uses outcome measures to evaluate and improve the quality of care received by patients enrolled in Medicare. Readmission measures capture unplanned readmissions that arise from acute clinical events requiring urgent rehospitalization within 30 days of discharge. Only an unplanned readmission to a short-term acute care hospital qualifies as a readmission. All unplanned readmissions are considered an outcome, regardless of cause.

Most outcome measures, including readmission measures, are designed to evaluate hospital performance and assess the quality of care provided to all patients, regardless of socioeconomic status. Evidence shows that patients negatively impacted by social determinants of health often experience lower quality of care and worse outcomes than other patients. The current models for the readmission measures do not adjust for social risk factors (SRFs).

This document completes the additional testing of SRFs for the 2024 MUC submission. We selected two SRFs for the additional testing: dual eligible (DE) status (enrolled in both Medicare and Medicaid) and area deprivation index (ADI) status. The testing results will answer the following questions:

1. How does the risk adjustment model perform in subgroups defined by the selected SRFs and how do they affect the model performance in the overall population?
  - We assessed the performance of the model in subgroups with and without the SRFs.
  - We added the two SRFs separately and then simultaneously into the current risk models which included the clinical risk factors only. We then examined the parameter estimates and statistical significances for the SRFs in the models with SRFs. Subsequently, we assessed the impact of adding SRFs on model performance.
2. How do the selected SRFs impact the measure scores?
  - We calculated and compared measure scores (i.e., risk-standardized readmission rate) with and without SRFs

## Methodology

### Data sources

We used one year (January 1, 2022 – December 30, 2022) of Medicare Fee-For-Service and Medicare Advantage administrative claims data. The dataset included inpatient and outpatient administrative data on each patient for the 12 months prior to the index admission and the 30 days following it. The dataset contained inpatient, outpatient and professional claims and Medicare enrollment data. For the SRFs, the dual eligible variable was obtained through enrollment data and ADI was obtained through Neighborhood Atlas data.

### Social risk factors

We selected SRF variables after reviewing the literature and examining available national data sources. We sought variables that are consistently captured in a reliable fashion for all patients in this measure. There is a large body of literature linking various SRFs to worse health status, greater use of the emergency department, and higher readmissions. Income, education, and occupation are the most commonly examined SRFs studied. Unfortunately, these variables are not available at the patient-level for this measure. Therefore, proxy measures of income, education level and economic status were selected.

The conceptual relationship, or potential causal pathways by which the possible SRFs influence the risk of unplanned readmissions following an acute illness or major surgery, like the factors themselves, are varied and complex. There are at least four potential pathways that are important to consider:

1. Patients with SRFs may have worse health at the time of hospital admission.
2. Patients with SRFs often receive care at lower quality hospitals.
3. Patients with SRFs may receive differential care within a hospital.
4. Patients with SRFs may experience worse health outcomes beyond the control of the health care system.

Although we analytically aimed to separate these pathways to the extent possible, we acknowledge that risk factors often act on multiple pathways simultaneously, and as such, individual pathways can be complex to distinguish analytically. Further, some SRFs, despite having a strong conceptual relationship with worse outcomes, may not have statistically meaningful effects on the risk model. They also have different implications on the decision to risk adjust or not. Based on these conceptual considerations, the SRFs used for the additional testing and the rationale were:

- Dual eligible status: Dual eligible (DE) status (i.e., enrolled in both Medicare and Medicaid) for a discharge is derived using the beneficiary enrollment data file in the Integrated Data

Repository (IDR). The data includes monthly enrollment status, and a patient is considered DE for an index admission if they are enrolled in both Medicare and Medicaid in the month of discharge date of the admission. Following guidance from the Office of the Assistant Secretary for Planning and Evaluation (ASPE) and a body of literature demonstrating differential health care and health outcomes among dual eligible patients, we identified dual eligibility as a key variable. We recognized that Medicare-Medicaid dual eligibility has limitations as a proxy for patients' income or assets because it is a dichotomous outcome and does not provide a range of values. However, the threshold for over 65-year-old Medicare patients is valuable, as this qualification takes into account both income and assets and is consistently applied across states for the older population.

- **Area Deprivation Index status:** The Area Deprivation Index (ADI) is a multidimensional measure of socioeconomic status of a geographical area. It considers 4 socioeconomic domains, including education, income/employment, housing, household characteristics. It measures at the census block group level and is calculated as a ranking from 0 to 100, with 0 meaning least deprived and 100 meaning most deprived. A census block group is a geographical unit used by the US Census Bureau and is the smallest geographical unit for which the bureau publishes sample data. The target size for block groups is 1,500, with a typical population of 600 to 3,000 people. We dichotomized the ADI rankings to greater than or equal to 85 (High ADI) versus less than 85 (Low ADI) per recommendation by the developer of ADI. For this analysis, we linked ADI at the census block group level to a 9-digit zip code.

## Statistical methods

We first assessed the relationship between the SRF variables with the outcome by summarizing the prevalence of SRFs across hospitals and comparing the readmission rate between patients with and without the SRFs. We also looked at the calibration plots to determine whether the original model predicts similarly well for different social risk groups.

Next, we examined the impact on model performance by adding the SRFs into the model. Specifically, we evaluated parameter estimates, and we also examined the extent to which the addition of any one of these variables improved model performance (c-statistic). Then, we calculated the hospital measure score differences and correlation coefficients of scores with and without the SRFs.

Lastly, our analyses revealed a slight underprediction for DE patients, so we sought to additionally investigate the relationship between the hospital proportion of DE patients and measure scores, as well as focusing on the quartile of hospitals with the highest proportion of DE patients.

## Results

### Prevalence of SRFs across measured entities

*Table 1. Variation in prevalence of SRFs across measured entities*

Condition / Procedure	Number of Hospitals (>=25 admissions)	Median Percentage of Prevalence, (IQR)	
		DE	High ADI
Acute Myocardial Infarction (AMI)	1728	10.26 (6.56 – 16.00)	9.57 (2.17 - 25.00)
Heart Failure (HF)	2799	16.19 (11.11 - 23.83)	11.49 (2.13 - 28.49)
Pneumonia	3121	20.14 (14.29 - 28.57)	11.90 (2.47 - 29.46)

Chronic Obstructive Pulmonary Disease (COPD)	2269	22.81 (16.00 - 31.25)	13.33 (2.82 - 31.07)
Total Hip Arthroplasty/Total Knee Arthroplasty (THA/TKA)	1483	5.76 (2.78 - 10.42)	6.52 (1.09 - 18.27)
Coronary Artery Bypass Graft (CABG)	851	5.15 (2.86 - 8.70)	10.00 (2.63 - 20.63)

[Table 1](#) shows that the prevalence of SRFs varied across measured entities. While the proportion of DE patients was higher than the proportion of high ADI patients for condition-specific readmission measures (AMI, HF, Pneumonia, COPD), the opposite trend was observed for procedure-specific measures (THA/TKA, CABG), where the proportion of high ADI patients was higher. Additionally, the proportion of DE or high ADI patients was higher for condition-specific readmission measures, compared to procedure-specific readmission measures.

*Table 2. Comparison of observed readmission rate (%) between patients with and without SRFs*

Condition / Procedure	Observed Readmission Rate (%)			
	DE	Non-DE	High ADI	Low ADI
AMI	17.71	12.40	14.07	12.89
HF	22.99	18.52	20.69	19.11
Pneumonia	18.58	14.77	16.57	15.44
COPD	21.60	16.88	18.41	17.93
THA/TKA	6.06	4.59	4.93	4.68
CABG	14.63	9.76	11.96	9.79

[Table 2](#) shows that patient-level readmission rate was higher for DE patients compared with non-DE patients. Similarly, the readmission rate for high ADI patients was higher compared with low ADI patients.

#### [Calibration plots for social risk groups](#)

Figure 1 presents the calibration plot for the overall AMI Readmission measure cohort. The x-axis is the decile ranked by patient-level predicted readmission rate and the y-axis is the mean of observed/predicted readmission rate that falls in the corresponding decile.

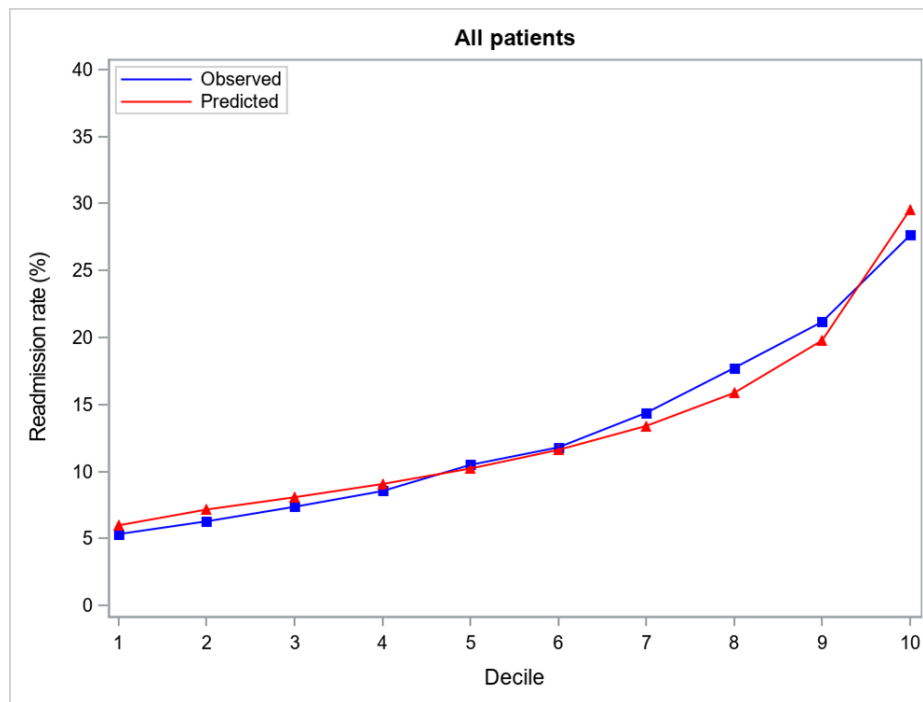


Figure 1. Calibration plot of AMI Readmission measure for all patients

Figure 1 shows there was a minimal difference across deciles between observed readmission rate and predicted readmission rate based on all patients for the AMI Readmission measure. It indicates that the original risk-adjustment model performed well in accurately predicting the readmission rate for all patients.

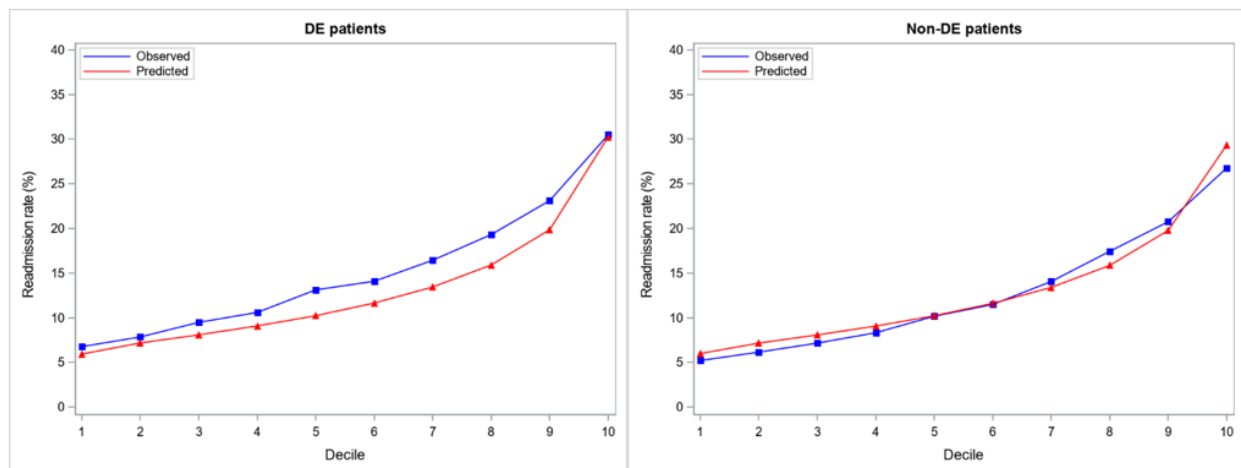


Figure 2. Calibration plot of AMI Readmission measure between DE/non-DE patients

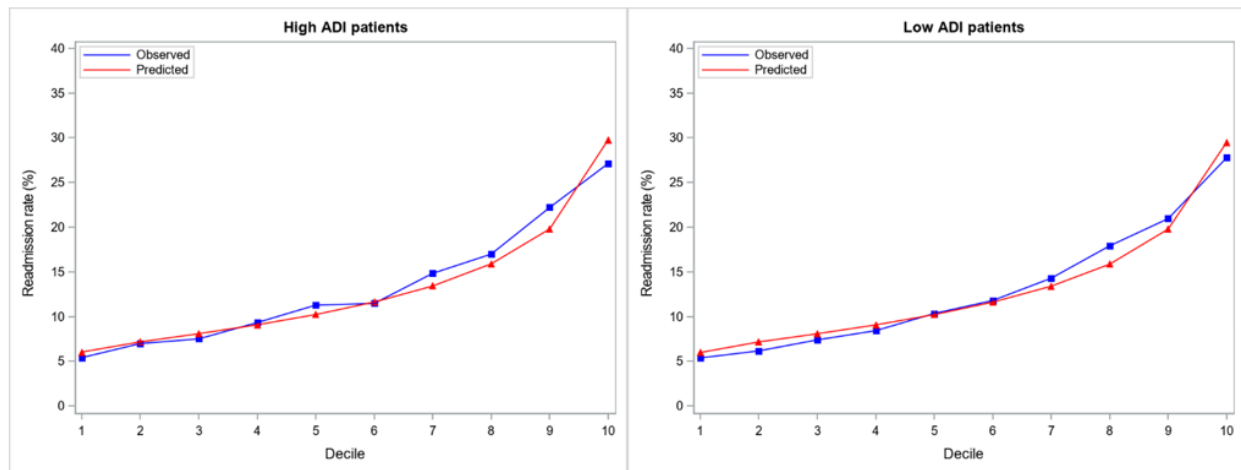


Figure 3. Calibration plot of AMI Readmission measure between high/low ADI patients

Figures 2 and 3 present the calibration plots for the AMI Readmission measure cohort stratified by DE and ADI status. From Figure 2, we observed that there was an underprediction of readmission rate for DE patients. The calibration plots in Figure 3 demonstrated that the model performed similarly well for both high and low ADI patients.

In addition, the calibration plots for other readmission measures in Appendix A also showed good calibration for high and low ADI patients while showing slight underprediction for DE patients.

#### Incremental effects of SRF variables in a multivariable model

Table 3 shows the estimated odds ratio with the corresponding 95% confidence interval of each SRF variable within the hierarchical logistic model when the two SRFs were added one at a time and both at the same time, to the original risk-adjustment model with the clinical risk factors included.

Table 3. Estimated odds ratio and 95% confidence interval of SRF variables

Condition / Procedure	SRF	Adding Either SRF Individually	Adding Both SRFs Simultaneously
AMI	DE	1.21 (1.17, 1.26)	1.22 (1.17, 1.26)
	High ADI	1.02 (0.99, 1.06)	1.02 (0.98, 1.05)
HF	DE	1.08 (1.07, 1.10)	1.08 (1.07, 1.10)
	High ADI	1.03 (1.01, 1.05)	1.03 (1.01, 1.04)
Pneumonia	DE	1.10 (1.08, 1.12)	1.10 (1.08, 1.12)
	High ADI	1.02 (1.00, 1.04)	1.02 (1.00, 1.04)
COPD	DE	1.09 (1.06, 1.12)	1.09 (1.06, 1.12)
	High ADI	0.97 (0.94, 1.00)	0.96 (0.93, 0.99)
THA/TKA	DE	1.15 (1.06, 1.24)	1.14 (1.06, 1.24)
	High ADI	1.01 (0.93, 1.08)	1.00 (0.93, 1.08)
CABG	DE	1.23 (1.13, 1.34)	1.22 (1.12, 1.33)
	High ADI	1.13 (1.06, 1.21)	1.13 (1.05, 1.21)

Across all the readmission measures, the odds ratio of DE was consistently positive whether added it to the model individually or simultaneously with high ADI, indicating that patients who are dually eligible had a higher probability of unplanned readmissions. However, high ADI presents a more variable association with unplanned readmissions. The association between unplanned readmissions and High ADI was positive in three readmission measures (HF, Pneumonia, and CABG) but was not significant or slightly negative in the other three (AMI, COPD and THA/TKA). Moreover, the strength of the association with DE was stronger compared to high ADI, as evidenced by the higher odds ratios for DE.

We also found that the c-statistics for the logistic model were almost unchanged with the addition of either or both SRFs into the model ([Table 4](#)).

*Table 4. C-statistic for models with and without SRFs*

Condition	Model			
	Base (without SRFs)	Base plus DE	Base plus high ADI	Base plus DE and high ADI
AMI	0.67	0.67	0.67	0.67
HF	0.64	0.64	0.64	0.64
Pneumonia	0.66	0.66	0.66	0.66
COPD	0.67	0.67	0.67	0.67
THA/TKA	0.67	0.67	0.67	0.67
CABG	0.65	0.65	0.65	0.65

#### [Impact on measure score](#)

We then examined the impact of adding each SRF separately on readmission measure scores, i.e., the national average readmission rate multiplied by the ratio of predicted and expected readmission rate at each hospital. We found that the addition of either SRF to the model had little to no effect on hospital performance, as measured by the distribution of absolute difference in measure scores and by the correlation coefficients between measure scores, with and without the SRFs ([Table 5](#)).

*Table 5. Differences in measure score and correlation coefficients comparing the measure model with and without each SRF*

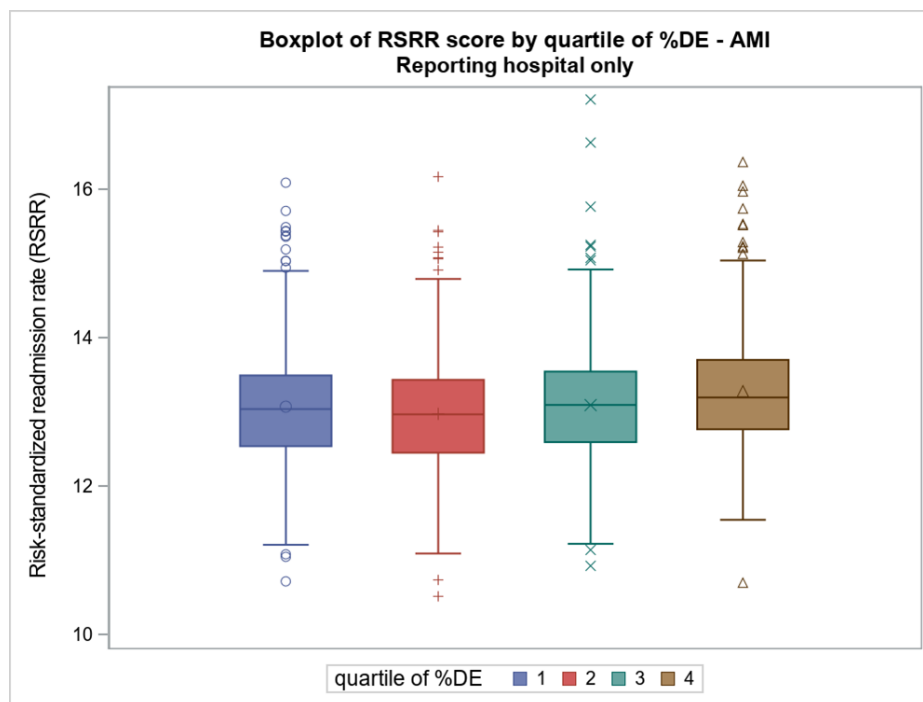
Condition	Metric	Absolute difference in measure scores (%)		Measure Score Correlation
	SRF	Median	IQR	Pearson Correlation Coefficient
AMI	DE	0.0000	-0.0000 – 0.0000	0.999
	High ADI	0.0002	0.0000 – 0.0004	0.989
HF	DE	0.0001	-0.0002 - 0.0003	0.999
	High ADI	0.0001	-0.0007 - 0.0009	0.988
Pneumonia	DE	0.0001	-0.0001 - 0.0002	0.999
	High ADI	0.0001	-0.0137 - 0.0007	0.987

COPD	DE	0.0000	-0.0002 - 0.0003	0.999
	High ADI	0.0002	-0.0006 - 0.0008	0.984
THA/TKA	DE	0.0000	-0.0000 - 0.0001	1.000
	High ADI	0.0002	0.0000 - 0.0004	0.987
CABG	DE	0.0001	-0.0001 - 0.0002	0.999
	High ADI	0.0003	-0.0003 - 0.0009	0.988

#### Relationship between measure score and proportion of patients with SRF

As we observed an underprediction for DE patients, we aimed to test the impact of such underprediction on hospitals with various proportions of DE patients. Therefore, we investigated the relationship between measure score and quartile of proportion of DE patients.

[Figure 4](#) presents the relationship between measure score (i.e., RSRR) and quartile of proportion of DE patients for the AMI Readmission measure. A great overlap of measure scores was observed across different quartiles of proportion of DE patients, suggesting that hospitals with more DE patients did not inherently have a significantly higher measure score.



*Figure 4. Boxplot of hospital RSRR score by quartile of proportion of DE patients – AMI readmission*

Additionally, the boxplot for other measures, shown in [Appendix B](#) indicated similar conclusions for other readmission measures.



## Summary

The analyses above showed that the observed readmission rate for patients with SRFs is higher. After adjusting for other clinical risk factors, patients who are dually eligible were at increased risk of unplanned readmissions, while the effect of high ADI was weaker, even insignificant or negative for some readmission measures. We believe that the clinical risk factors account sufficiently for patients with SRFs and the overall effect of these SRFs on the measure score was deemed minimal. First, the models calibrated well in subgroups stratified by SRFs without adding the SRFs. Second, the estimated risk-standardized measure scores for hospitals with and without adjusting for either social risk factor were highly correlated. Third, the differences in measure scores between the social-risk-factor unadjusted and adjusted measures were minimal. Finally, a substantial overlap of measure score was observed across different quartiles of proportion of dual patients, suggesting that hospitals with more dual patients did not inherently have a higher risk of unplanned readmissions. Although there was a slight positive association between measure score and proportion of DE patients, the readmission measures are stratified by the proportion of DE patients as part of the CMS Hospital Readmissions Reduction Program (HRRP) calculations. Given these findings and the complex pathways that could explain any relationship between social risk and unplanned readmissions, we did not incorporate social risk variables into the measures.

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## Appendix A. Calibration plots for HF, Pneumonia, COPD, THA/TKA, and CABG readmission measures

### 1. HF Readmission

Table 6. Calibration plot of HF Readmission measure for all patients

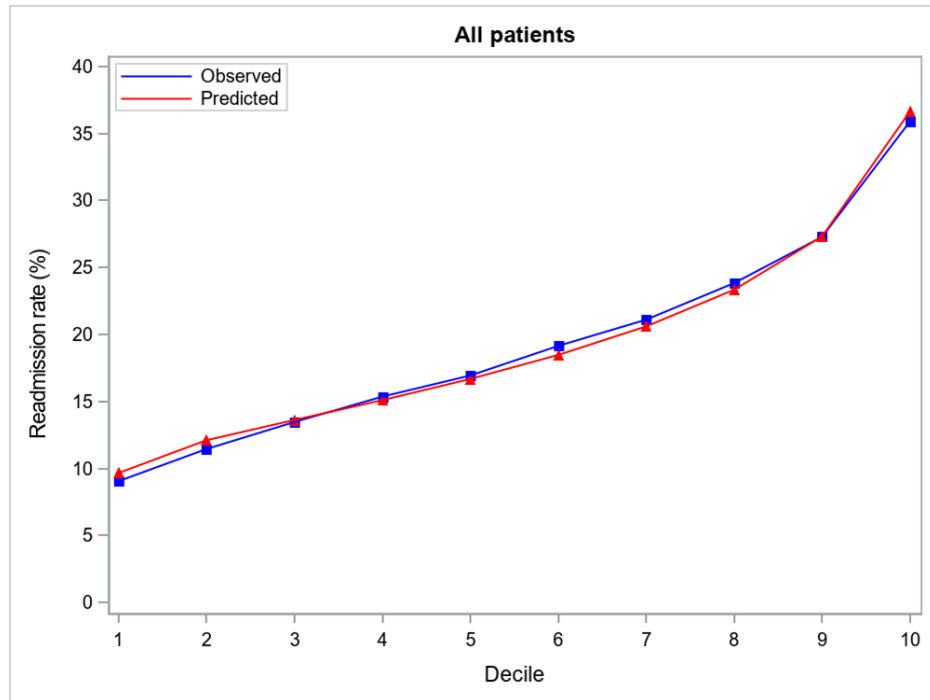


Table 7. Calibration plot of HF Readmission measure between DE/non-DE patients

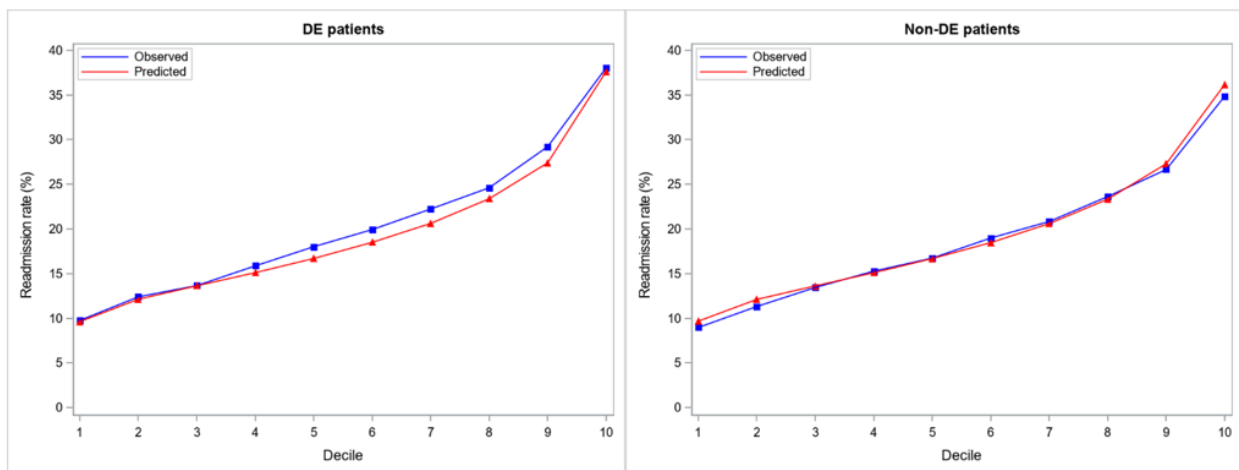
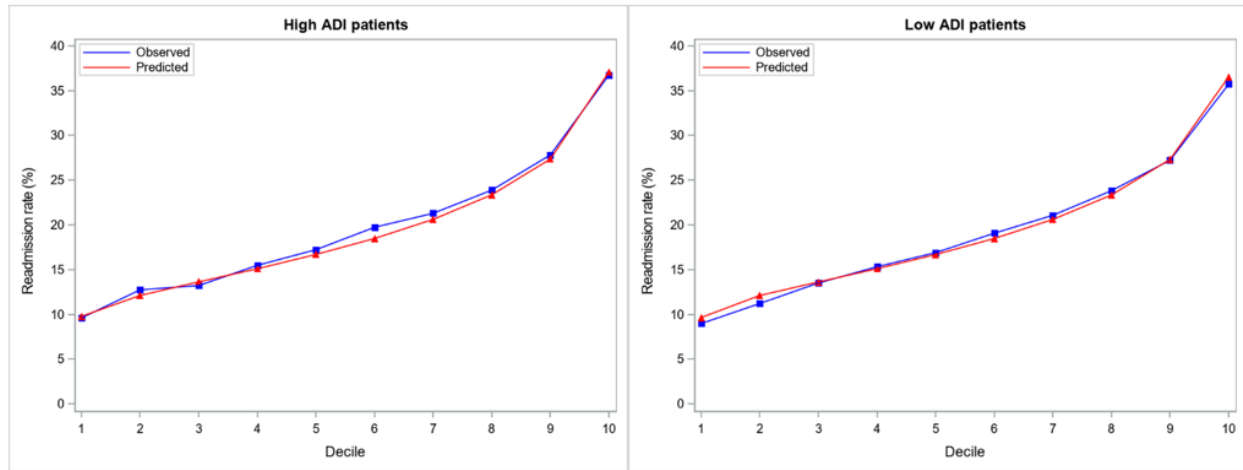


Table 8. Calibration plot of HF Readmission measure between high/low ADI patients



## 2. Pneumonia Readmission

Table 9. Calibration plot of Pneumonia Readmission measure for all patients

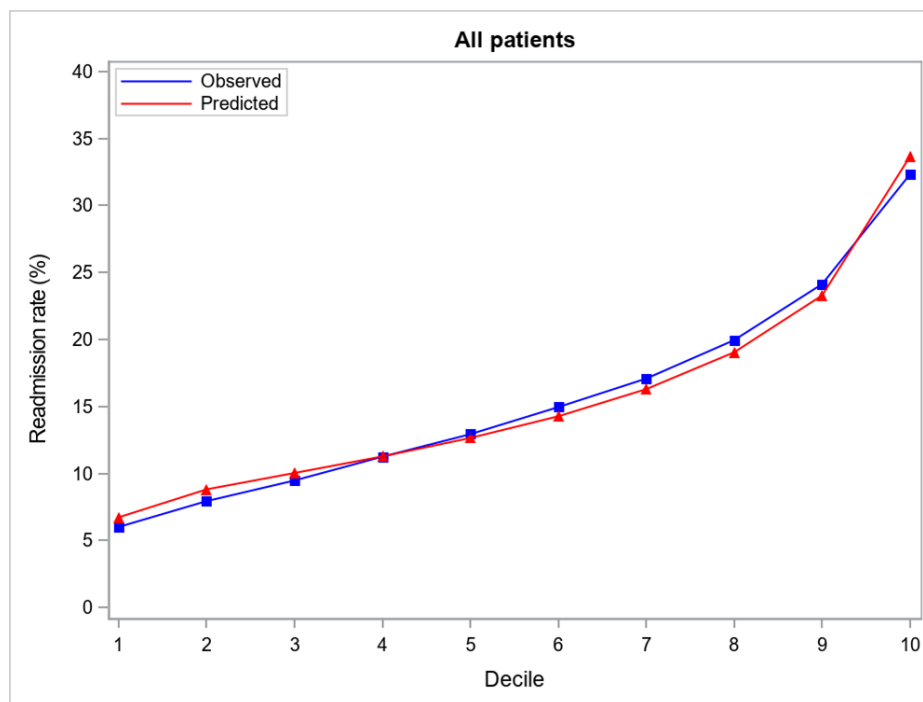


Table 10. Calibration plot of Pneumonia Readmission measure between DE/non-DE patients

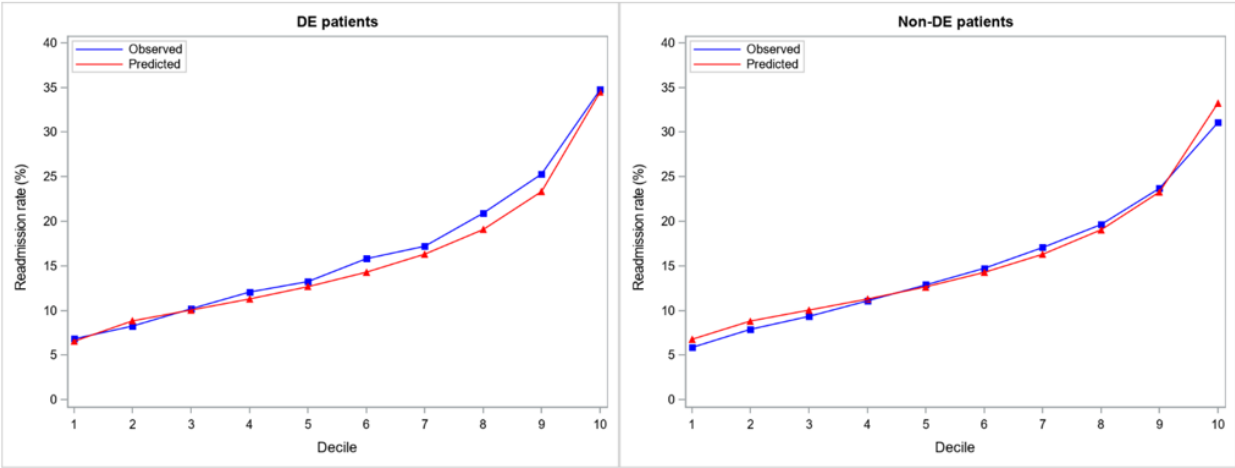
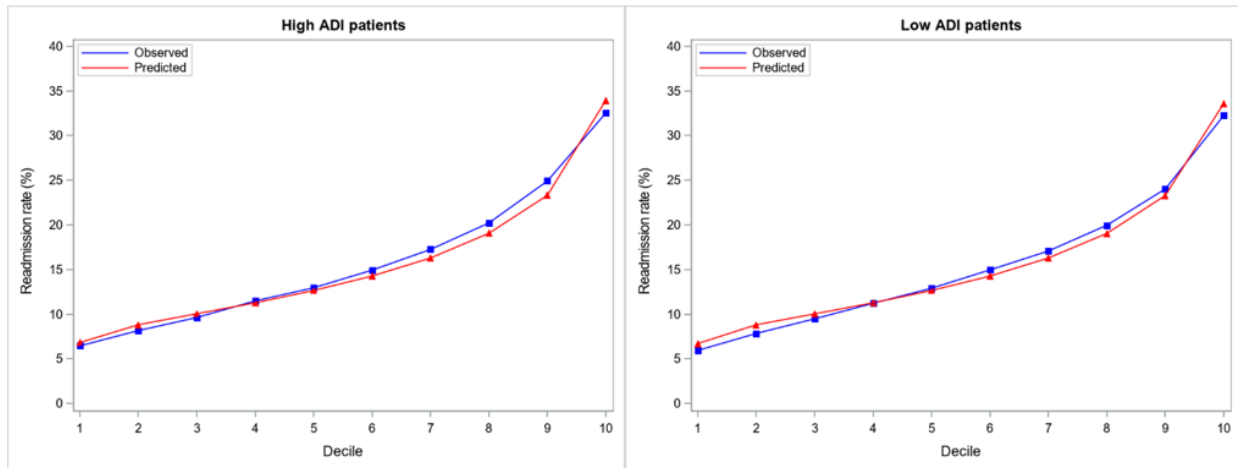


Table 11. Calibration plot of Pneumonia Readmission measure between high/low ADI patients



### 3. COPD Readmission

Table 12. Calibration plot of COPD Readmission measure for all patients

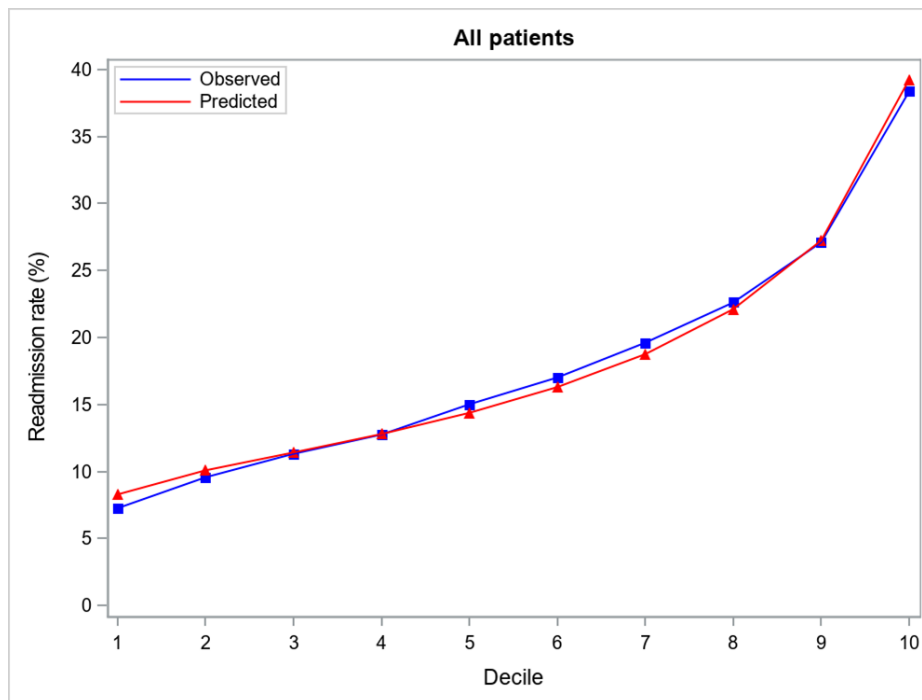


Table 13. Calibration plot of COPD Readmission measure between DE/non-DE patients

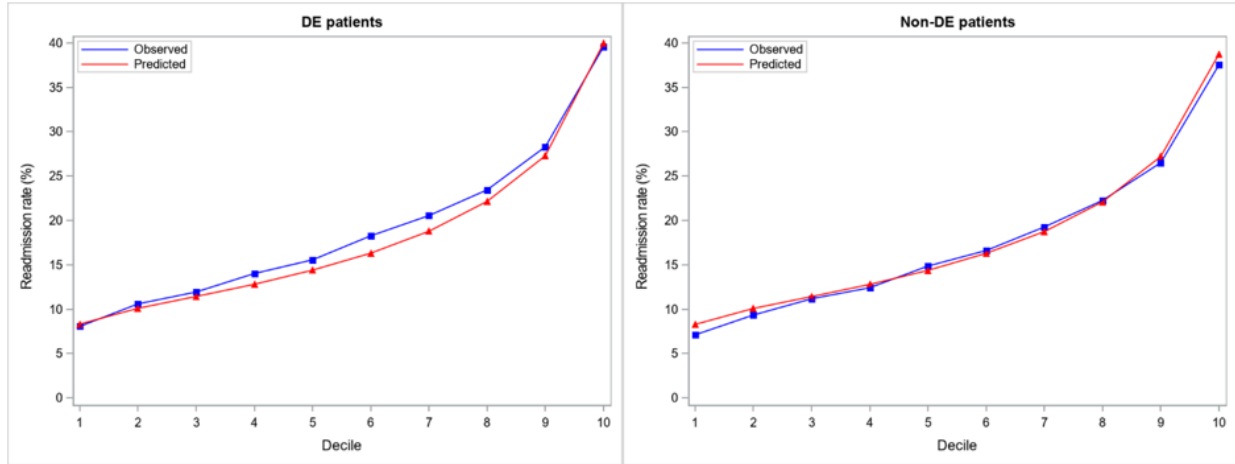
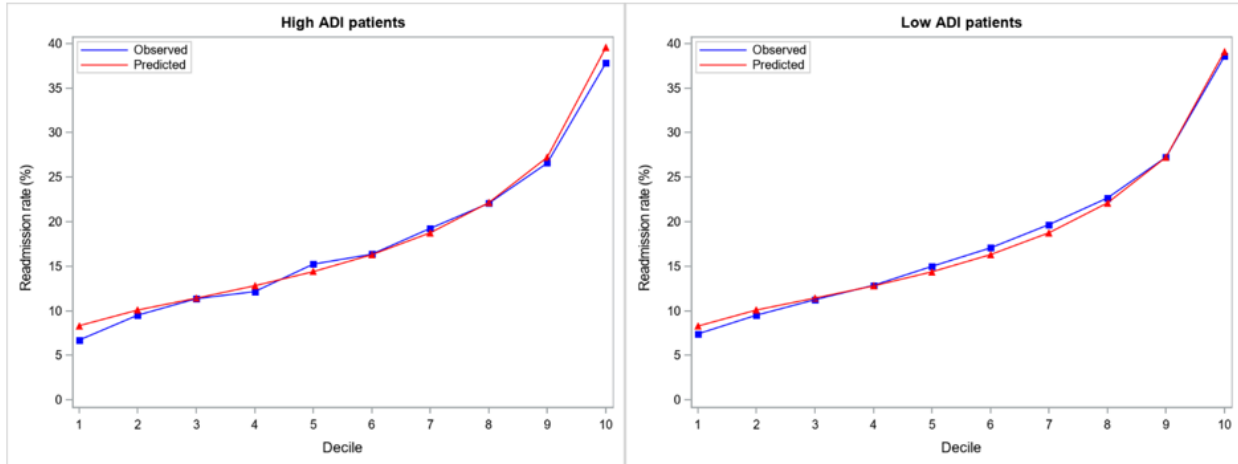


Table 14. Calibration plot of COPD Readmission measure between high/low ADI patients





#### 4. THA/TKA Readmission

Table 15. Calibration plot of THA/TKA Readmission measure for all patients

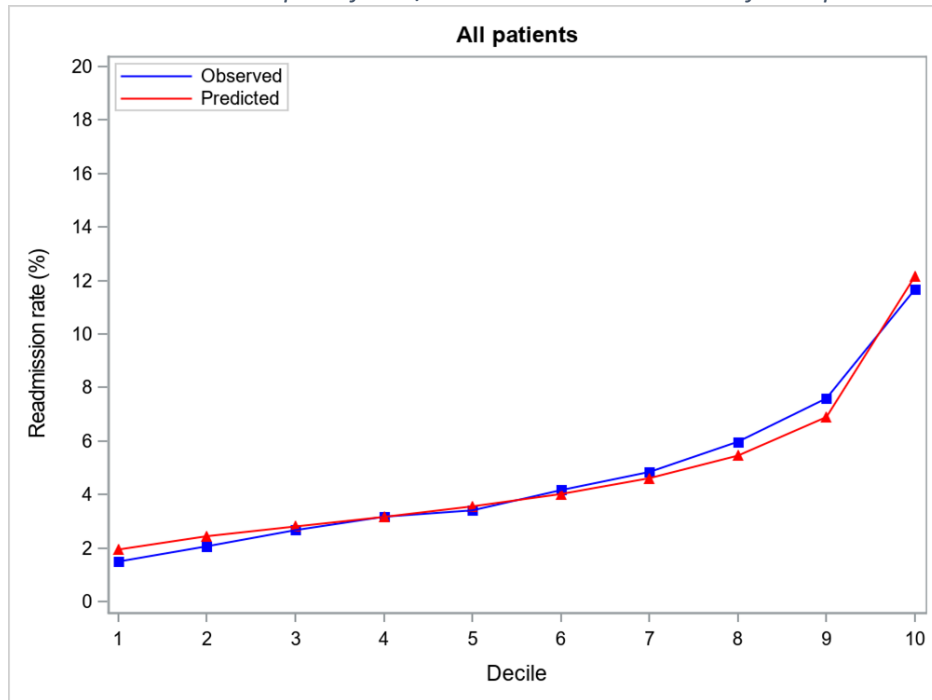


Table 16. Calibration plot of THA/TKA Readmission measure between DE/non-DE patients

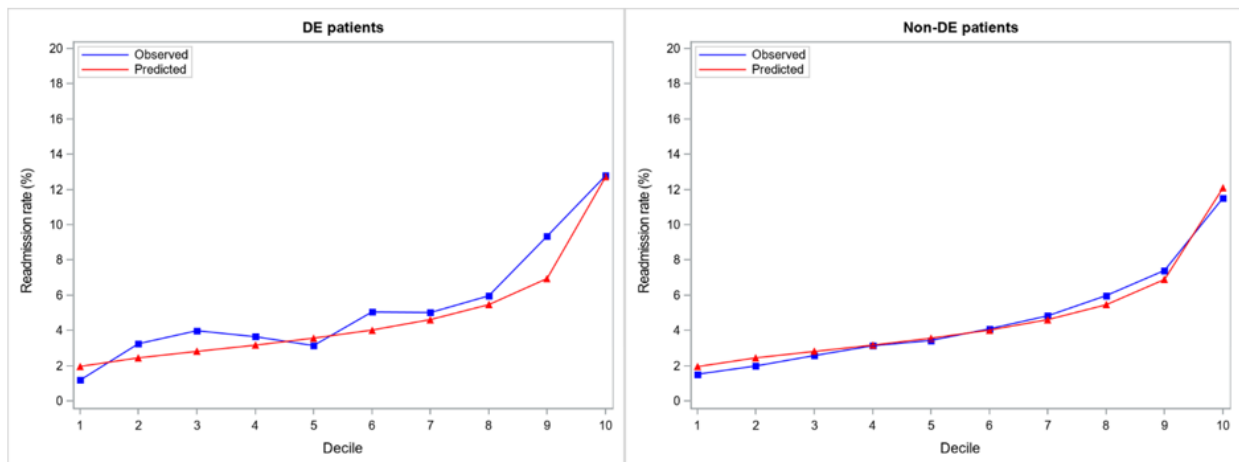
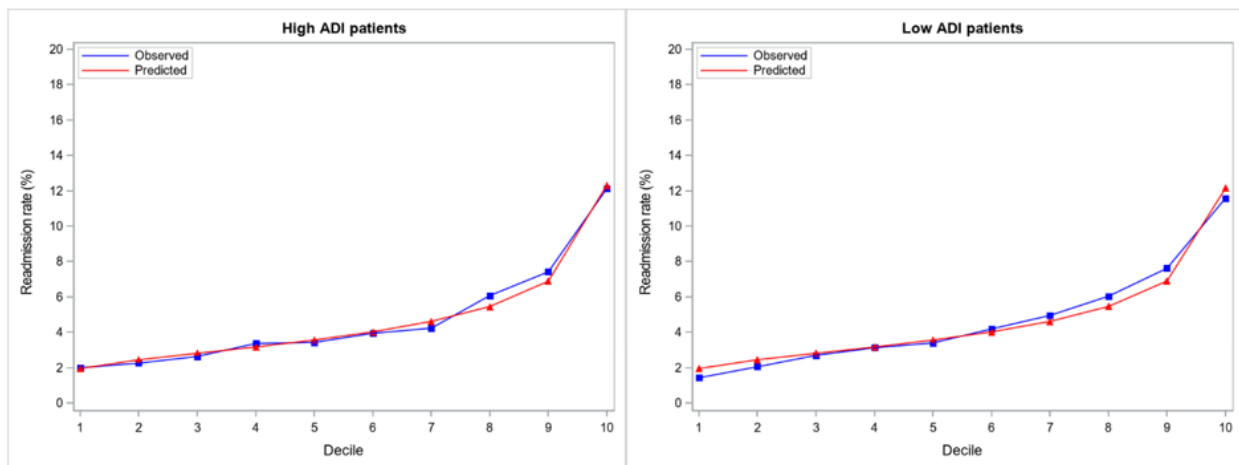


Table 17. Calibration plot of THA/TKA Readmission measure between high/low ADI patients



## 5. CABG Readmission

Table 18. Calibration plot of CABG Readmission measure for all patients

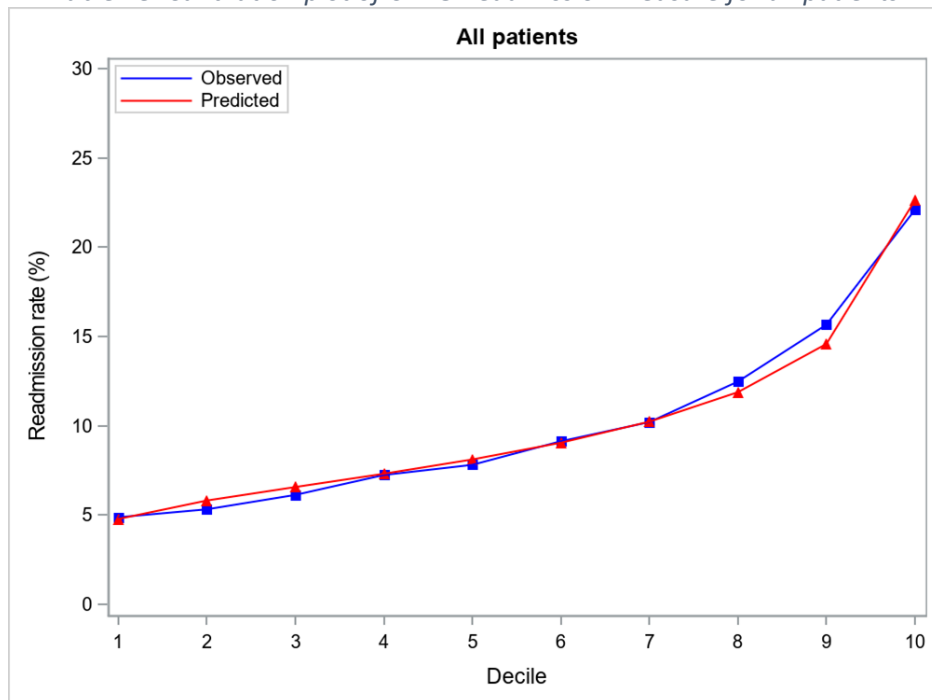


Table 19. Calibration plot of CABG Readmission measure between DE/non-DE patients

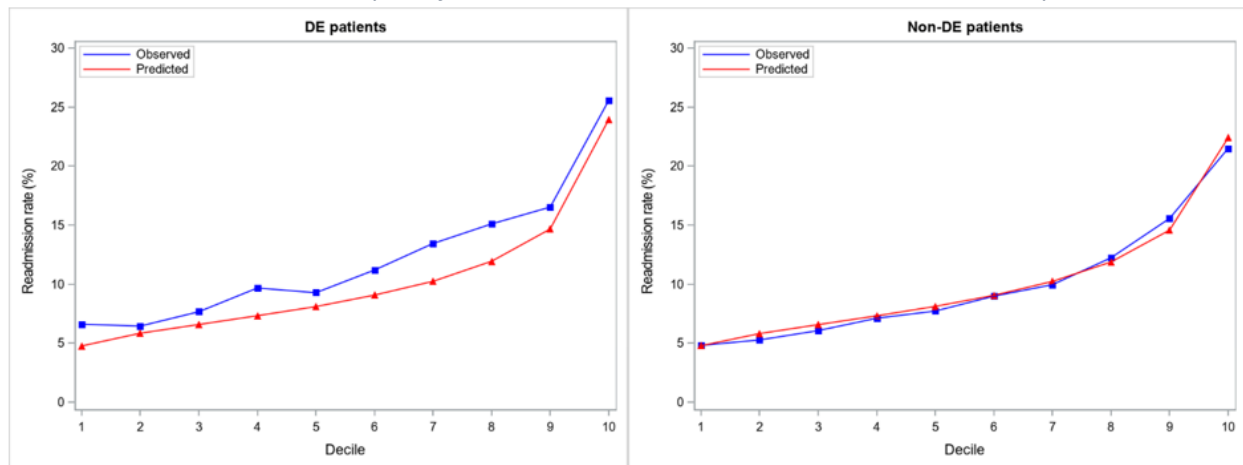
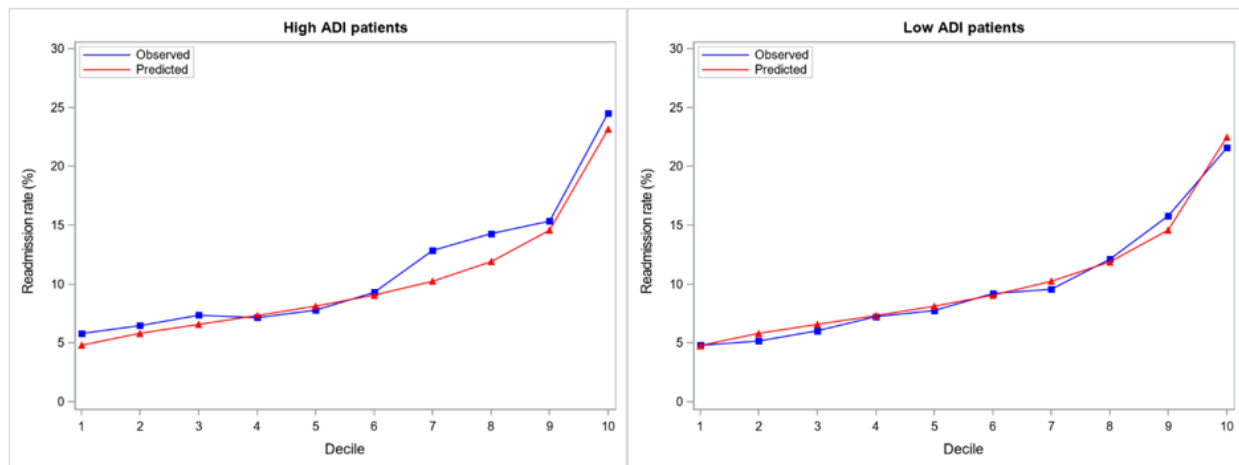
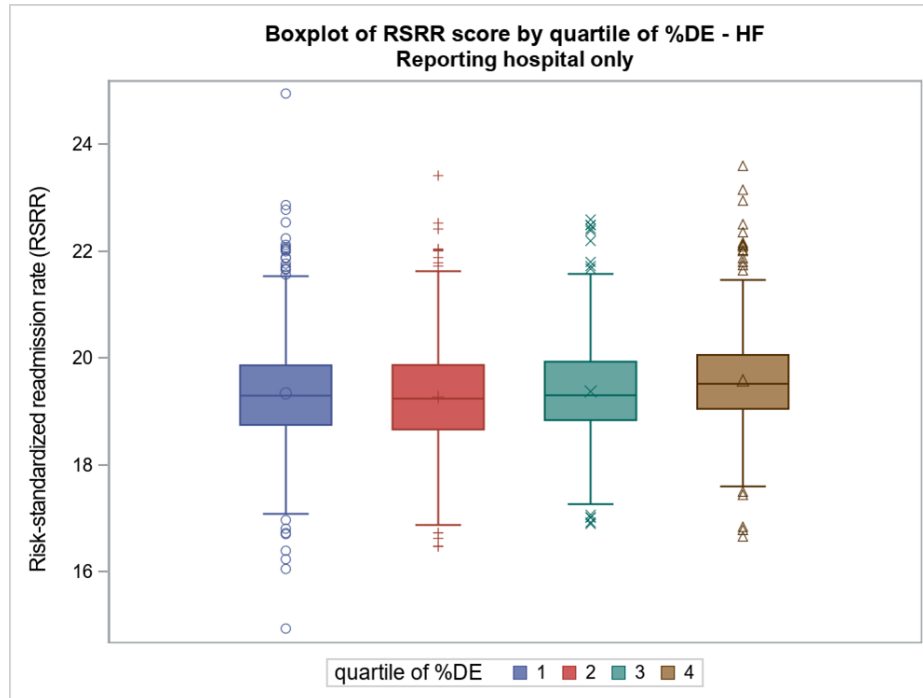


Table 20. Calibration plot of CABG Readmission measure between high/low ADI patient

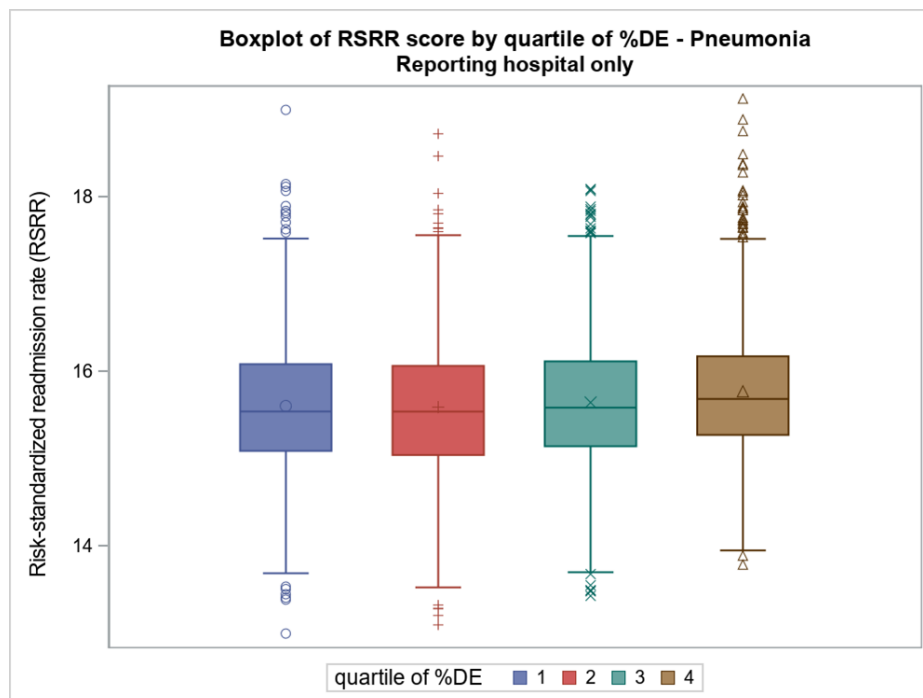


## Appendix B. Boxplot of hospital RSRR score by proportion of DE patients for HF, Pneumonia, COPD, THA/TKA, and CABG readmission measures

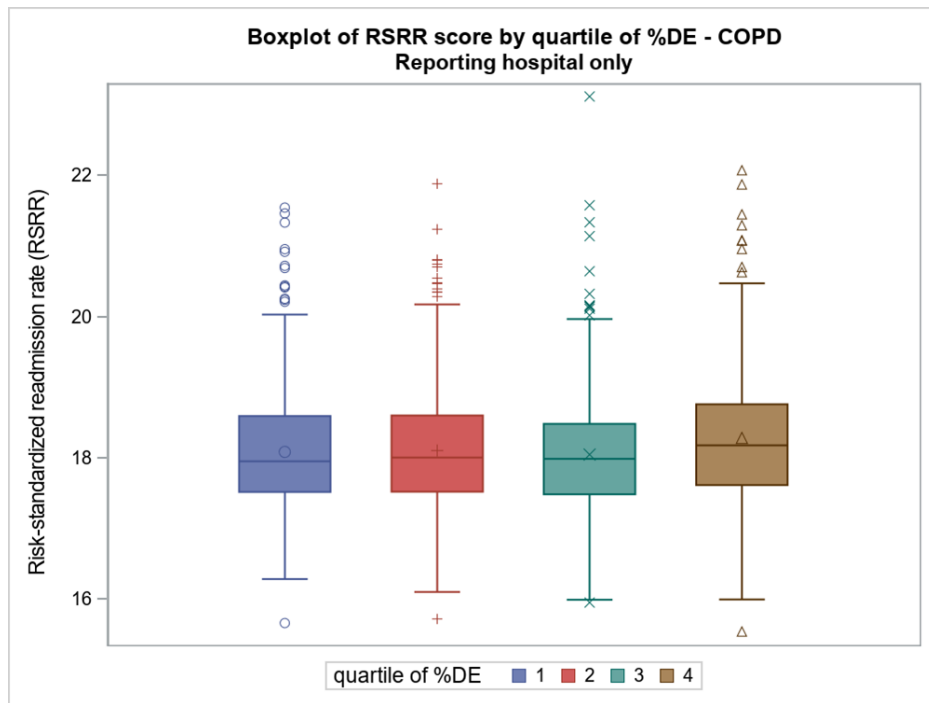
### 1. HF Readmission



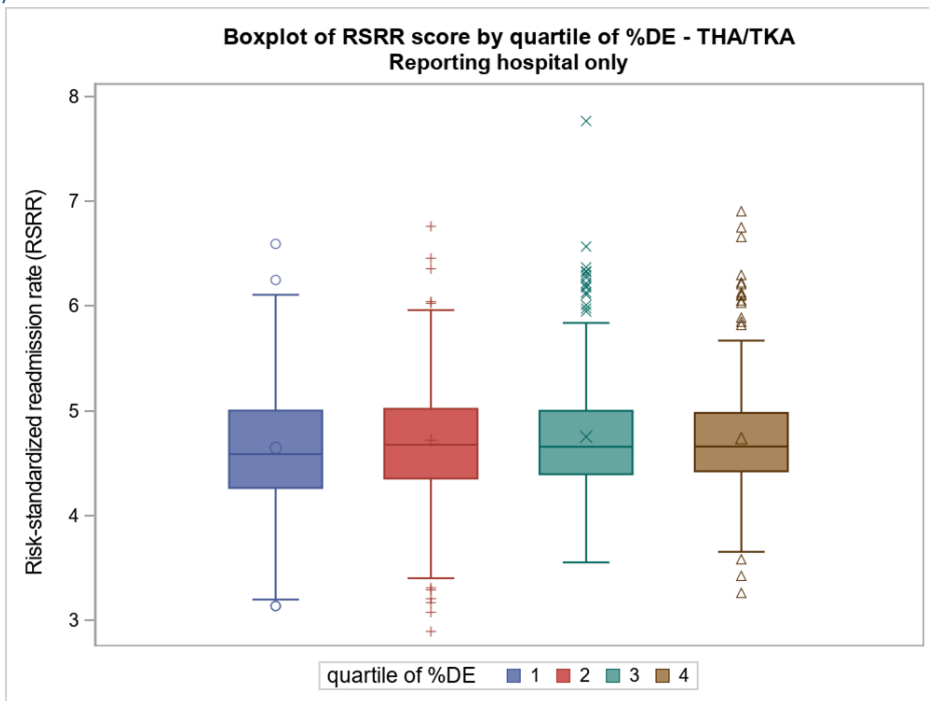
### 2. Pneumonia Readmission



### 3. COPD Readmission



### 4. THA/TKA Readmission



## 5. CABG Readmission

