**Supplementary Material**

 Supplement Table 1. Patient characteristics associated with 30-day readmissions

|  |  |  |
| --- | --- | --- |
| **Patient characteristic** | **Patients (%)**N = 3,951 | **30-Day Readmission Rate** (%) |
| Age category < 65 years 65-84 years ≥ 85 years | 505 (12.8)2,032 (51.4)1,414 (35.8) |  23.4 *a*19.0 *b*18.7 *b* |
| Gender Female  Male | 2,341 (59.2)1,610 (40.8) |  23.3 *c*16.8 *d* |
| Race Non-Hispanic White Black or African-American Hispanic/Latino Asian Other/Unknown | 2,998 (72.3)752 (19.1)201 ( 5.1)116 ( 2.9)24 ( 0.6) | 18.6 *a*22.7 *b* 18.924.1 *b*0.0 |
| Preferred language English Farsi Russian Spanish Other Non-English | 2,956 (74.8)331 ( 8.4)769 ( 9.2)135 ( 3.4)164 (4.2) | 18.9 *c*19.3 *a*17.8 *a* 24.4 29.9 b, *c* |
| Payer Medicare FFS Dual Eligible Other | 1,812 (45.9)1,696 (42.9)443 (11.2) | 16.8 *c*22.6 *d*18.5 *c* |
| Hospital Clinical Service Line Orthopedic surgery General Internal Medicine General Surgery Cardiology – Medical Cardiology – Interventional Gastroenterology Pulmonary Neurology Other surgical Psychiatry Other service | 1,016 (25.7) 814 (20.6) 337 ( 8.5) 327 ( 8.3) 79 ( 2.0)275 ( 7.0)294 ( 7.4)242 ( 6.1)311 ( 7.9) 20 ( 0.5)236 ( 6.0) | 11.2 a,*c*21.7 *d*22.3 *d*26.9 *d*20.3 b25.5 *d*26.5 *d*16.9 b17.0 b 15.0 22.9 *d* |
| APR-DRG Severity of Illness (n = 3,946) Minor Moderate Major Extreme  | 318 ( 8.1)1,072 (27.2)1,706 (43.2)852 (21.6) | 10.7 *c*10.4 *c*21.6 *d*29.8 *e* |
| Index hospitalization length of stay 1 to 3 days 4 to 5 days 6 to 9 days > 9 days | 992 (25.1)965 (24.4)1,062 (26.9)932 (23.6) | 12.6 15.1 *c* 20.7 *d* 29.8 *e* |
| Totals may not add to 100% due to rounding.*a*differs from *b* at p < 0.05*c, d* and *e* differ from each other at p < 0.001 |

RESULTS OF STRATIFIED ANALYSES

The multivariate logistic regression was repeated within specific strata of the study population as a further test of whether the results were affected by differences in the ECP and non-ECP patient characteristics. When the analysis was restricted to Dual Eligible patients (n = 1,683), the odds ratio for ECP was 0.77 (95% CI 0.60 – 0.99; p = 0.042). The total population included only 751 African American patients, but even so, the odds ratio was 0.71 with p = 0.064 (95% CI 0.49 – 1.02). Considering only patients who were not admitted to the highest volume facility (n = 1,988), the program odds ratio was 0.75 (p = 0.015, 95% CI 0.60 - 0.95). Finally, considering patients who had any condition other than orthopedic surgery (n = 2,912), the odds ratio was 0.73 (p = 0.001, 95% CI 0.61 – 0.88). Similar results were obtained when the study population was restricted to patients living within the medical center’s primary service area, and to patients living in zip codes in which the proportion of adults living in households with income below 100% of the poverty level was 15% or greater.

PROPENSITY ANALYSIS

*Methodology*:

Likelihood ratio tests were performed to verify if the clusters Skilled Nursing Facilities (SNF) and Payers explained a significant amount of variability.

A multivariable logistic mixed model considering only SNF as clusters was applied to predict the group (ECP group compared to non-ECP group) after adjusting for Age, Gender, Race, Preferred Language, Payer, Hospital Clinical Service Line, APR-DRG Severity and Index Hospital Length of Stay.

Balance in baseline covariates were assessed using standardized absolute differences (%) as suggested by Austin and Stuart (2015), but the methodology is extended to incorporate cluster weights.

The standardized difference for a binary variable within the cluster $h$ is defined as

$$d\_{h}=\frac{^\_{T}-^\_{C}}{\sqrt{\frac{^\_{T}(1-^\_{T})^\_{C}(1-^\_{C})}{2}}}$$

for $i=1,...,nc$ where $nc$ is the number of clusters, $p\_{T}$ and $p\_{C}$ are the prevalence of the binary variable in treated and control subjects, respectively. Then, it is possible to define the overall standardized difference for a binary variable,

$$D=\sum\_{h=1}^{nc}\frac{w\_{h}×d\_{h}}{w\_{h}}$$

where $w\_{h}$ is the weight of the cluster $h$.

Then a multivariable logistic model with Inverse Probability of Treatment Weighting (IPTW) to predict readmission after adjusting for the same variables considered in the propensity score analysis was performed. Odds ratio with their respective 95% confidence intervals are presented.

In addition, Average Treatment Effect (ATE) was calculated following Li et al. (2013) with 95% confidence intervals based on bootstrap samples. We extended this idea to calculate the Average Treatment Effect on Treated (ATT) and on Control (ATC) as follows.

A nonparametric clustered estimator for Average Treatment Effect (ATE) within the cluster $h$ is

$$^\_{h}=\frac{\sum\_{k=1}^{n\_{T}h}w\_{hTk}Y\_{Thk}}{w\_{hT}}-\frac{\sum\_{k=1}^{n\_{C}h}w\_{hCk}Y\_{Chk}}{w\_{hC}}$$

where $w\_{hTk}=1/^\_{hgk}$ and $w\_{hCk}=1/(1-^\_{hgk})$ such that $^\_{hgk}$ is the estimated propensity score for patient $k$ from group $g$ (g = T:Treatment, g = C: Control) within the cluster $h$, $w\_{hg}=\sum\_{k=1}^{n\_{gh}}w\_{hgk}$ and $Y\_{hgl}$ is the binary outcome for the patient $k$ from group $g$ within cluster $h$.

Then, the overall estimator for ATE follows

$$^=\sum\_{h=1}^{nc}\frac{w\_{h}×^\_{h}}{w\_{h}}$$

where $w\_{h}=\sum\_{k=1}^{n\_{g}}\sum\_{k=1}^{n\_{hg}}w\_{hgk}$.

In order to estimate the average treatment effect on treated patients (ATT), the weights are defined as $w\_{hTk}=1$, $w\_{hCk}=^\_{hgk}/(1-^\_{hgk})$ and for the average treatment effect on control patients (ATC), $w\_{hTk}=(1-^\_{hgk})/^\_{hgk}$, $w\_{hCk}=1$.
Results were considered statistically significant if p value smaller than 0.05. All analyses were done using R package version 3.2.3 (R Core Team, 2016).

*Results*:

Supplement Table 2 indicates that only clusters defined by the SNFs explains are statistically significant (p < 0.001).

Supplement Table 2. Likelihood tests to evaluate presence of clusters

|  |  |
| --- | --- |
| Hypothesis | p value |
| no clusters vs SNF | < 0.001 |
| No clusters vs Payer | 1 |
| SNF vs SNF + Payer | 1 |

When the full logistic regression model was run using IPTW (Supplement Table 3), the odds ratio on readmission increased to 0.77 (p = 0.004, 95% CI 0.64 – 0.92), compared with 0.71 in the original model. There were no significant changes in most of the characteristics associated with increased odds of 30-day readmission: being male, Hispanic, speaking a language other than English, Russian or Farsi, being Dual Eligible, and being discharged from a clinical service line of General Internal Medicine, Medical Cardiology, Gastroenterology, or Pulmonary. Being a Spanish speaker became significant with p = 0.044 compared with 0.069 in the original model, and the odds ratio increased from 1.83 to 1.92. Having an index hospital stay of 1 to 3 days was no longer significant, but the odds ratio for having an index stay of 10 days or greater increased from 1.45 to 2.00 (p < 0.001, 95% CI = 1.49 – 2.68). At the same time, the Major and Extreme discharge Severity of Illness scores were no longer statistically significant, with the 95% confidence interval for the Extreme category broadening from 1.66 – 2.97 (p < 0.001) to 0.97 - 2.52 (p = 0.066).

Supplement Table 3. Propensity-weighted multivariable logistic regression: odds of 30-day same hospital readmission from Skilled Nursing Facilities

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Odds Ratio** | **(95% CI)** | **p-Value** |
| ECP participation | 0.77 | (0.64 - 0.92) | 0.004 |
| Age category |  |  |  |
|  < 65 years | 1.16 | (0.87 - 1.55) | 0.301 |
|  65-84 years | Reference |  |  |
|  ≥ 85 years | 1.04 | (0.84 - 1.28) | 0.713 |
| Gender |  |  |  |
|  Male | 1.36 | (1.13 - 1.63) | 0.001 |
|  Female | Reference |  |  |
| Race |  |  |  |
|  White | Reference |  |  |
|  Black or African-American | 1.09 | (0.86 - 1.37) | 0.484 |
|  Hispanic/Latino | 0.52 | (0.3 - 0.93) | 0.027 |
|  Asian | 0.87 | (0.5 - 1.51) | 0.627 |
|  Other | [dropped] | NA | NA |
| Preferred Language |  |  |  |
|  English | Reference |  |  |
|  Russian | 0.76 | (0.53 - 1.10) | 0.143 |
|  Farsi | 0.82 | (0.58 - 1.16) | 0.26 |
|  Spanish | 1.92 | (1.02 - 3.62) | 0.044 |
|  Other non-English  | 1.75 | (1.12 - 2.74) | 0.015 |
| Payer |  |  |  |
|  Medicare Fee-For-Service | Reference |  |  |
|  Dual Eligible | 1.44 | (1.06 - 1.95) | 0.018 |
|  Other | 0.99 | (0.72 - 1.36) | 0.968 |
| Hospital Clinical Service Line |  |  |  |
|  Orthopedic surgery | Reference |  |  |
|  General Internal Medicine | 1.34 | (0.99 - 1.81) | 0.057 |
|  General Surgery | 1.14 | (0.77 - 1.69) | 0.52 |
|  Cardiology – Medical | 1.68 | (1.19 - 2.39) | 0.004 |
|  Cardiology – Interventional | 1.98 | (1.34 - 2.92) | 0.001 |
|  Gastroenterology | 1.61 | (1.07 - 2.41) | 0.022 |
|  Pulmonary | 0.91 | (0.59 - 1.39) | 0.651 |
|  Neurology | 0.90 | (0.61 - 1.34) | 0.617 |
|  Other surgical | 1.34 | (0.99 - 1.81) | 0.057 |
|  Psychiatry | 1.80 | (0.47 - 6.81) | 0.389 |
|  Other service | 1.35 | (0.89 - 2.03) | 0.159 |
| APR-DRG Severity |  |  |  |
|  Minor | 0.75 | (0.48 - 1.18) | 0.21 |
|  Moderate | Reference |  |  |
|  Major | 0.75 | (0.48 - 1.18) | 0.21 |
|  Extreme | 0.75 | (0.48 - 1.18) | 0.21 |
| Index Hospital Length of Stay |  |  |  |
|  1 to 3 days | 0.75 | (0.56 - 0.99) | 0.046 |
|  4 to 5 days | 0.80 | (0.61 - 1.05) | 0.107 |
|  6 to 9 days | Reference |  |  |
|  > 9 days | 1.60 | (1.25 - 2.05) | < 0.001 |

The Average Treatment Effect associated with the ECP was a reduction in the readmission rate of -5.1% (95% CI -7.9% to -2.5%). The Average Treatment Effect on the Treated was -5.3% (95% CI -8.2% to -2.4%) and the Average Treatment Effect on the Controls was -4.7% (95% CI -7.5% to -1.9%). The evaluation of standardized cluster differences between the ECP and non-ECP groups before and after Inverse Probability Treatment Weighting (Supplement Figure 1) showed that the differences were reduced to less than 10% for being African American, speaking Russian or Farsi, having Dual Eligible insurance coverage, Orthopedic surgery, being discharged from the clinical service lines of Gastroenterology, Pulmonary, Other Surgery, and Other Services, and having an index hospital LOS of 4 to 5 days or 10 or more days.

Supplement Figure 1. Standardized cluster differences between ECP and Non-ECP groups before and after Inverse Propensity Treatment Weighting



SUPPLEMENT REFERENCES

1. R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
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2. Li F, Zaslavsky AM, Landrum MB. Propensity score weighting with multilevel data. *Statistics in Medicine* 2013; 32: 3373-3387.
3. Austin PC, Stuart EA. Moving towards best practice when using inverse probability of treatment weighting (IPTW) using the propensity score to estimate causal treatment effects in observational studies. *Statistics in Medicine* 2015; 34: 3661-3679.