

## **SUPPLEMENT**

### **Supplemental Methods**

#### **Identifying Hospitals with IRF Unit Closures for Study Inclusion**

We used the 100% sample of IRF PAI assessments, combined with the Provider of Service files, to identify hospitals which closed their IRF units between 2009 and 2017. We then assessed the volume of stroke hospitalizations, and the rate of discharge to the IRF setting before/after (+/- 2 years) closure; hospitals were included only if they maintained a stable volume of stroke hospitalizations following closure, and experienced at least a 25% (relative) reduction in IRF discharges. After applying these criteria, we identified fifty-five hospitals for inclusion in the study.

#### **Covariates**

Each hospitalization was characterized using 224 total covariates across the following domains: beneficiary demographics, enrollment, historical and current clinical diagnoses, settings of residence prior to hospitalization, and additional information derived from the index hospitalization records. Their data sources included:

##### *Medicare Beneficiary Summary File (MBSF)*

The MBSF was used to identify beneficiary demographics (age, sex, and race), enrollment information (current and original reason for Medicare entitlement, Medicaid partial or full dual-eligibility, and for determining continuous traditional Medicare enrollment prior and subsequent to hospitalization).

##### *Medicare Provider Analysis and Review (MedPAR) file and Inpatient Hospital Standard Analytic File (SAF)*

The inpatient hospitalization Standard Analytic File (SAF) for the years 2007-2010 and the MedPAR file for the years 2011-2019 were used to identify index stroke and hip fracture hospitalizations along with the following information: ICD diagnosis and procedure codes, length of stay (LOS), and both intensive care unit (ICU) and

coronary care unit (CCU) utilization (any use, and the count of days used). ICD diagnosis and procedure codes were grouped into clinically meaningful categories using the Healthcare Cost and Utilization Project's (HCUP) Clinical Classifications Software (CCS).<sup>1</sup> ICD diagnosis codes were also characterized using the Elixhauser comorbidity classification system into thirty comorbidity group indicators.<sup>2</sup> A previously validated approach was applied to generate a mortality risk-index based on the set of Elixhauser comorbidity condition indicators.<sup>3</sup>

#### *Hospitals Experiencing IRF unit closure: the IRF-PAI and Provider of Service File*

We measured longitudinal trends in case volume among Hospital-based IRF units between 2007 and 2019 using the Inpatient Rehabilitation Facilities-Patient Assessment Instrument (IRF-PAI). For any hospital-based IRF unit which ceased submitting IRF-PAI records between 1/1/2007 and 12/31/2017, we established an estimated *closure* date (based on the latest submission date, after removing outliers). Next, we validated our estimated IRF unit closure dates using the Provider of Service (POS) file, which records the historical termination dates of rehabilitation units. The POS was also used to characterize hospitals by geography and bed count.

#### *Chronic Conditions Warehouse (CCW)*

We constructed binary indicators for prior diagnosis with any of the 27 original Chronic Conditions Warehouse (CCW) chronic conditions, plus the 40 conditions included among the expanded CCW set of *Other Chronic Health, Mental Health, and Potentially Disabling Conditions*.

#### *Residential History File*

We identified the patient residence during the period prior to and subsequent to each stroke hospitalization using a residential history file (RHF), which combines claims, assessments, and enrollment data to establish daily historical Medicare beneficiary residence.<sup>4</sup> During the 180-day period prior to hospitalization, we summarized the count of days patients resided at home, in nursing homes, in hospitals, or other settings. We also identified the setting of residence (i.e., IRF, SNF, HH, or home without services) immediately prior to hospitalization for each case. Lastly, we constructed post-acute episodes following the index hospitalization which combine the initial post-acute discharge setting and all subsequent post-acute settings (e.g. IRF followed by a HH episode) uninterrupted by death, hospitalization, or disenrollment.<sup>5</sup>

### *Outcomes*

Mortality was determined using the death information recorded by the MBSF, and all-cause hospital readmissions were identified using the inpatient hospital SAF for the years 2007-2010 and the MedPAR file for the years 2011-2019

## **Statistical Methods**

### **Cross-temporal matching approach**

#### *Overview*

The cross-temporal matching approach allows the identification of the three main groups of patients present in an instrumental variables (IV) framework. Those that comply with the change in treatment (*Compliers*) from IRF to SNF or HH, those that continue with the IRF treatment (*Always Takers*), and those that never took the treatment (*Never Takers*).<sup>6</sup> These groups can then be used in a difference-in-differences (DiD) model where the *Compliers* are the treatment group and the *Never Takers*—those that used SNF (or HH) before or after IRF closure—are the control group.

The cross-temporal matching design approach follows a three-step approach to identify these three groups. First, we identified IRF patients in the pre-closure period similar to those who continued to use IRF in the post-closure period (*Always Takers*). In our case, a small portion of patients were discharged to free-standing IRFs during the post-closure period, suggesting that certain patients have a greater propensity for using IRF (and are capable/willing to travel outside of their hospital facility to receive IRF care). We did this by fitting a multinomial propensity score model for post-acute discharge setting selection to IRF, SNF, and HH, using cases during the post-closure period ( $\hat{p}_{post}^T$ ). This post-period propensity score model  $\hat{p}_{post}^T$  is used on the pre-period cases to obtain their propensity scores and at that point we used this three-dimensional vector of generalized propensity scores (GPS)  $\hat{p}_{post}^T$  to match each post-period IRF user to an IRF user in the pre-period, providing our identified group of *Always Takers*.<sup>7,8</sup>

Next, to identify the *Compliers*, we note that the remaining pre-period IRF-users not matched to the post-period IRF users are indeed those most likely to comply with the IRF-closure and switch to a non-IRF setting. To identify their non-IRF counterparts in the post-closure period (those who would have been discharged to IRF had the IRF unit not closed), we fit a similar multinomial propensity score model during the pre-closure period ( $\hat{p}_{pre}^T$ ). This pre-closure GPS was used with the post-period sample to obtain their  $\hat{p}_{pre}^T$  estimates so we can match each complier in the pre-period to a post-period non-IRF user to complete the group of *Compliers*. Lastly, we used  $\hat{p}_{pre}^T$  to match non-IRF users during the pre-closure period who were unaffected by the closures with similar non-IRF users during the post-closure period to identify the control group of *Never Takers*.

### *Propensity score estimation*

Propensity scores were generated to capture the estimated probability of each case being discharged to IRF, SNF or home with HH. To train models capable of producing reliable propensity scores, we used the large set of input predictors across the following domains: demographics, enrollment information, stroke type, hospitalization measures, the Elixhauser mortality index (and 29 clinical conditions); CCW chronic conditions;

and lastly, a set of HCUP CCS derived indicators for medical conditions and procedures diagnosed during the patient's hospitalization (excluding diagnosis/procedure classifications with less than 1% prevalence/incidence in our sample). Any condition indicators which were duplicated across the set of CCW conditions, Elixhauser conditions, and CCS conditions were removed.

We assigned each case as either pre or post closure, and defined the treatment ( $T$ )—first discharge setting (IRF, SNF, Home w HH)— as a categorical variable ( $t \in T$ ) with three discrete levels ( $t_{snf}$ ,  $t_{irf}$ ,  $t_{hh}$ ), one for each discharge setting. Propensity score models for the multi-class treatment were fit independently using pre and post closure observations, using the extreme gradient boosting (XGBoost) algorithm.<sup>9,10</sup> We tuned our models using the max-depth, learning rate, maximum tree-depth, and sub-sampling ratio hyperparameters (among others), optimizing for minimum cross-validated log-loss with 1,000 rounds of 5-fold cross-validation. This method produces two vectors (with three dimensions) of generalized propensity scores (GPS) represented by  $\hat{p}_{Period}^T$  where *period* indexes the pre & post closure periods.<sup>7</sup> Due to frequency imbalance across treatment settings, SNF, IRF, and HH were weighted in the final XGBoost training cohort to avoid overfitting XGBoost on overrepresented treatments.

For the hip fracture cohort, which only included discharges to IRF or SNF, we estimated a binary propensity score model for the probability of discharge to IRF.

### *Vector Matching*

Given a categorical treatment variable, the propensity to be assigned to any individual treatment group  $t \in T$  is insufficient for identifying well matched pairs (e.g.  $t_{SNF}$  to  $t_{IRF}$ ) for purposes of causal effect estimation. For example, if we matched SNF cases to IRF cases ( $SNF^{Post}$ ,  $IRF^{Pre}$ ) using only  $\hat{p}_{pre}^{IRF}$ , then we would ignore potentially important variation across the remainder of the GPS vector ( $\hat{p}_{pre}^{HH}$ ), resulting in biased estimates.<sup>8,11</sup> To ensure that our matching approach accounts for variation across the entire GPS vector, we applied a vector matching method<sup>12</sup>:

*Step 1:* To match  $IRF^{Pre}$  cases with  $IRF^{Post}$  cases, we first fit clusters across  $\hat{p}_{post}^{SNF}$  and  $\hat{p}_{post}^{HH}$  using the K-means clustering (KMC) algorithm. Next, we match  $IRF^{Pre}$  to  $IRF^{Post}$  using 1:1 nearest-neighbors matching without replacement with  $\hat{p}_{post}^{IRF}$  as our distance metric. Matching is conducted within KMC cluster and hospital, and we apply a matching caliper such that matches are only selected if the two cases are within .25 SD of the propensity score. We thereby produce a set of matched pairs of IRF Always Takers ( $IRF_{AT}^{Pre}$  and  $IRF_{AT}^{Post}$ ).

*Step 2:* The  $IRF^{Pre}$  cases not selected as Always Takers for  $IRF_{AT}^{Pre}$  represent the set of Compliers  $IRF_{CO}^{Pre}$  in the pre period that will switch to SNF or HH care in the post IRF-closure period. To model the switch to SNF, we fit (KMC) clusters across  $\hat{p}_{pre}^{HH}$  and matched  $SNF^{Post}$  to  $IRF_{CO}^{Pre}$  using m:1 caliper matching (caliper = .25 SD) within cluster and within hospital, with replacement, and with  $\hat{p}_{pre}^{IRF}$  as our distance metric. We repeated this logic to identify matches of those that switched to HH in the post period,  $HH^{Post}$ , and  $IRF_{CO}^{Pre}$  cases (KMC:  $\hat{p}_{pre}^{SNF}$ ; distance:  $\hat{p}_{pre}^{IRF}$ ). Matching weights were calculated based on the number of times a case was selected. We thereby produce matched pairs for SNF Compliers ( $IRF_{CO}^{Pre}$  and  $SNF_{CO}^{Post}$ ), and HH Compliers ( $IRF_{CO}^{Pre}$  and  $HH_{CO}^{Post}$ ).

*Step 3:* Modifying our approach from *Step 2*, rather than matching *across* treatment levels (e.g.,  $IRF_{CO}^{Pre}$  to  $SNF^{Post}$ ), in *Step 3* we match *within* treatment levels of non-IRF settings to produce matched pairs of SNF Never Takers ( $SNF_{NT}^{Pre}$  and  $SNF_{NT}^{Post}$ ), and HH Never Takers ( $HH_{NT}^{Pre}$  and  $HH_{NT}^{Post}$ ).

### *Balance assessment*

For each matching group (IRF Always Takers, SNF Compliers, HH Compliers, SNF Never Takers, and HH Never Takers) we assessed the pre- and post-closure balance of the covariates using the absolute standardized mean differences (ASMD). We used a 10% threshold for acceptable standardized differences, in accordance with recommendations found in the literature.<sup>13-15</sup> Each covariate's ASMD was assessed independently, and then pooled across all covariates used in the models.

### *Propensity Score Overlap*

To ensure the robustness of our matching approach and assess potential violations of the positivity assumption, we examined the distributions of propensity scores across comparison groups. As shown in Supplemental Figure 1, the propensity score distributions for IRF, SNF, and home health (HH) discharges demonstrated substantial overlap between pre- and post-closure periods, as well as between matched groups (e.g., SNF-to-SNF vs. IRF-to-SNF). This overlap confirms that our matching procedure was able to identify comparable patients across discharge settings and time periods, minimizing concerns about extrapolation beyond the support of the data. The balanced distributions further validate our assumption that the instrument (IRF closure) did not create systematic differences in patient characteristics that could bias our estimates.

To evaluate positivity, we examined propensity score distributions across comparison groups. **Supplementary Figure 2** depicts the distribution of propensity scores (for each setting in our multinomial model) for stroke patients from our SNF vs IRF comparison. Overlap was sufficient for reliable matching, with rare extremes (<5% of scores) trimmed to avoid extrapolation. Standardized mean differences (Table 2) further confirmed balance post-matching.

### **Difference in Differences Treatment Effect Models**

We fit separate models to estimate the treatment effect of IRF relative to SNF, and IRF relative to HH using a difference in differences framework. To estimate the effect of IRF on patient outcomes relative to SNF, we compared changes in outcomes between the pre and post-closure period among SNF Compliers ( $IRF_{CO}^{Pre}$  and  $SNF_{CO}^{Post}$ ) with changes in outcomes among SNF Never Takers ( $SNF_{NT}^{Pre}$  and  $SNF_{NT}^{Post}$ ) as the control group. Our regression specification takes the form,

$$Y = a_0 + a_1CO + a_2Post + \gamma CO * Post + \beta_1X + \delta + \varepsilon$$

in which  $CO$  identifies the selected matched pairs of compliers,  $Post$  is an indicator for the post-closure period,  $X$  is a vector of covariates to adjust for residual differences after matching, and  $\delta$  is a set of fixed effect terms for each of the fifty-five hospitals included in our analysis. The coefficient  $\gamma$  captures our difference in differences estimate of the treatment effect of switching from IRF to SNF care. The same approach was used to estimate the DID treatment effect estimate for our comparison of IRF relative to HH.

## Tables and Figures

**Supplementary Table 1:** Post-Matching Balance, Stroke

	Always Takers			Compliers			Never Takers		
	IRF <sub>pre</sub>	IRF <sub>post</sub>	Std. Diff.	IRF <sub>pre</sub>	SNF <sub>post</sub>	Std. Diff.	SNF <sub>pre</sub>	SNF <sub>post</sub>	Std. Diff.
N (Weighted)	540	540		704	704		868	868	
N (Unweighted)	540	540		704	506		868	868	
Age	75.51	75.24	2.71	79.84	79.65	1.95	82.26	82.98	7.48
Sex: Female (%)	50.93	49.07	3.70	55.40	60.72	10.71	65.33	64.37	2.01
Race: White (%)	77.78	76.48	3.06	87.07	86.72	1.06	86.76	85.63	3.34
Race: Black (%)	13.89	11.85	6.31	5.54	4.40	4.96	7.06	5.49	6.12
Any Dual Medicaid Status (%)	17.41	20.74	-8.23	18.61	22.59	10.21	26.31	24.61	3.86
Hospital LOS (days)	5.12	5.50	-10.42	5.05	5.06	0.15	6.48	6.04	9.39
ICU (%)	54.63	52.22	4.82	41.05	38.49	5.19	36.32	39.02	5.61
CCU (%)	26.85	25.37	3.41	22.30	21.09	2.90	20.47	22.13	4.10
Elixhauser Mortality Score Setting Prior to Hospitalization: from NH (%)	3.69	3.34	4.84	4.43	4.34	1.08	5.00	4.98	0.28
Stroke Type: Hemorrhagic (%)	0.37	0.56	-2.49	2.41	3.41	6.47	17.07	18.81	4.63
CCW, N of Chronic Conds.	13.89	10.00	12.97	10.09	10.37	0.94	11.67	11.98	0.95
CCW: ADRD (%)	8.59	8.78	-5.32	9.98	10.18	5.93	10.73	11.08	10.84
CCW: CHF (%)	14.26	18.70	-11.41	26.28	26.85	1.29	48.52	53.40	9.76
CCW: COPD (%)	43.52	38.70	9.88	52.13	50.99	2.27	57.32	58.54	2.46
CCW: Depression (%)	27.22	29.63	-5.27	42.76	42.12	1.29	40.21	42.64	5.06
CCW: Cataracts (%)	24.63	29.07	-9.79	30.97	34.45	7.52	37.20	43.51	13.06
CCW: Osteoporosis (%)	58.70	59.44	-1.51	73.86	71.66	5.01	78.66	81.75	7.54
CCW: Anemia (%)	12.59	15.56	-8.18	22.87	25.14	5.41	31.01	34.49	7.53
CCW: Hypertension (%)	55.74	57.96	-4.50	65.48	68.96	7.31	70.47	76.61	13.46
Paralysis (%)	95.56	95.00	2.55	95.45	96.31	4.09	96.34	97.39	5.57
Other nervous system (%)	59.81	53.52	12.63	32.81	41.34	18.14	31.36	35.10	8.07
UTI (%)	64.63	68.33	7.95	48.58	55.54	13.92	50.26	58.67	16.80
DM w/o Comp. (%)	11.30	11.85	1.72	15.20	15.13	0.20	20.38	18.73	4.11
Echocardiogram (%)	26.30	22.04	10.28	22.87	25.36	5.91	24.65	22.21	5.66
Gastrostomy; temp/perm (%)	7.78	8.15	-1.35	6.39	7.67	5.22	5.05	3.83	5.57
	2.41	4.26	-9.18	2.70	2.91	1.31	7.23	6.79	1.68

Resp. Intubation and MV (%)	2.41	3.89	-7.67	2.27	1.99	1.90	3.40	3.40	0.00
<b>Unmatched ASMD</b>			<b>10.57</b>			<b>15.70</b>			<b>4.44</b>
<b>Matched ASMD</b>			<b>6.38</b>			<b>4.90</b>			<b>6.11</b>
<b>Rubin's B-Statistic</b>			<b>0.30</b>			<b>0.84</b>			<b>0.47</b>
<b>Rubin's R-Statistic</b>			<b>109.63</b>			<b>100.42</b>			<b>100.20</b>

Abbreviations: LOS = length of stay; ICU = intensive care unit; CCU = cardiac care unit; NH = nursing home; CCW = chronic conditions warehouse; AD RD = Alzheimer's disease & related dementias; COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure; UTI = urinary tract infection; TCI = transient cerebral ischemia; DM = diabetes mellitus; MV = Mechanical Ventilation.

**Supplementary Table 2:** Characteristics of Hip Fracture Patients Discharged to PAC Before and After IRF-Unit Closure

	Discharge Setting							
	SNF		IRF		HHA		Home	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Total								
Hospitalizations, N (%)	3,859	5,132	2,384	759	505	531	406	387
	53.94%	75.37%	33.32%	11.15%	7.06%	7.80%	5.68%	5.68%
<i>Change</i>		21.43%		-22.18%		0.74%		0.01%
Age	83.6	83.1	80.9	80.0	77.2	77.6	77.9	76.8
Sex: Female (%)	76.0	74.1	74.1	74.3	71.1	74.2	61.8	59.9
Race: White (%)	93.6	92.6	93.8	93.4	89.3	87.8	91.6	89.9
Race: Black (%)	2.8	2.9	2.8	3.3	5.5	4.3	3.7	3.9
Enrollment: OASI (%)	88.4	87.4	88.9	89.9	80.2	80.6	79.6	77.8
Enrollment: Disability (%)	11.1	12.3	10.8	9.2	18.4	17.9	19.7	21.4
Dual-enrolled in Medicaid (%)	27.4	24.3	14.1	9.9	22.6	23.0	20.9	19.1
hospital LOS (days)	6.1	5.7	5.0	5.2	5.2	4.6	5.4	6.0
ICU (%)	17.1	16.7	16.9	17.1	12.5	13.6	19.0	20.7
CCU (%)	3.9	5.0	4.2	6.1	3.4	3.6	5.2	5.4
Elixhauser Mortality Score	6.0	6.1	4.7	5.2	4.4	5.0	6.2	6.9
CCW Chronic Conditions (N)	11.5	11.4	10.2	10.4	9.8	10.1	9.9	9.7
Setting Prior to Hospitalization: NH (%)	19.2	13.5	1.3	0.4	0.6	1.7	6.4	7.5
CCW: AD RD (%)	54.5	48.1	23.4	28.5	29.1	33.3	36.2	36.2
CCW: CHF (%)	53.7	51.5	45.0	40.7	41.8	43.3	47.8	41.1
CCW: COPD (%)	46.4	47.3	41.0	39.9	39.8	45.2	45.6	40.3
CCW: Osteoporosis (%)	51.2	50.7	48.4	49.7	45.1	45.6	39.7	41.6
CCW: Cataracts (%)	81.2	82.0	79.4	79.1	69.5	69.1	66.3	61.8
CCW: Hypertension (%)	93.3	93.6	90.0	91.3	88.1	86.4	85.7	85.3
CCW: Anemia (%)	89.3	88.7	84.9	88.3	78.4	80.6	77.6	76.7
CCW: Depression (%)	51.9	50.4	39.7	44.4	43.4	48.2	41.4	46.3
CCW: Atrial Fib. (%)	30.3	30.2	26.3	25.6	21.4	18.8	24.9	23.5
CCW: Chronic Kidney Disease (%)	44.2	47.9	35.5	44.9	36.8	41.1	39.7	41.9
CCW: Diabetes (%)	40.9	40.9	35.3	35.0	37.8	37.9	33.7	39.0

CCW: Hyperlipidemia (%)	76.3	80.3	77.8	78.8	74.1	74.6	69.5	65.9
CCW: Ischemic Heart Disease (%)	68.4	67.4	63.2	59.7	57.8	57.4	63.1	56.6
CCW: Stroke/TIA (%)	31.8	30.7	27.1	24.6	23.6	24.9	23.9	24.3
Septicemia (except in labor) (%)	1.7	1.4	0.8	1.4	2.0	1.7	4.4	5.7
Rheumatoid arthritis and related disease (%)	2.1	3.1	2.7	3.2	2.8	3.2	4.9	2.3
Diabetes mellitus with complications (%)	5.1	6.2	4.2	5.9	3.6	6.6	2.7	8.5
Other fractures (%)	18.7	17.0	10.7	18.7	22.0	20.5	18.7	20.4
Acute posthemorrhagic anemia (%)	32.2	31.3	34.0	39.1	17.2	21.1	20.9	19.4
Secondary malignancies (%)	1.4	1.4	1.5	2.1	3.2	4.9	5.7	4.9
Acute myocardial infarction (%)	2.0	1.3	1.4	0.4	0.6	0.8	3.4	3.1
Coronary atheroscl. & other heart disease (%)	27.5	28.5	25.4	27.3	22.0	20.3	28.6	25.8
Chronic skin ulcer (%)	4.1	3.2	2.3	1.4	4.0	3.8	5.2	4.1
Acute and unspecified renal failure (%)	12.9	12.5	8.9	11.9	6.3	6.8	15.3	14.7
Other nutritional; endocrine; and metabolic disorders (%)	11.8	15.9	10.5	15.3	10.3	16.4	14.3	20.9
Nutritional deficiencies (%)	11.5	10.5	5.9	5.9	7.9	10.7	10.3	17.8
Phlebitis; thrombophlebitis and thromboembolism (%)	3.9	4.6	3.6	4.6	3.0	4.1	6.9	5.7
Respiratory failure; insufficiency; arrest (adult) (%)	7.6	8.2	5.2	6.7	7.7	6.0	12.1	13.4
Hip replacement; total and partial (%)	28.2	31.8	36.7	33.6	24.0	24.1	19.5	23.3
Blood transfusion (%)	37.6	31.8	36.0	31.5	22.6	20.2	21.7	21.4
Fx tx incl. reposition w/ or w/o fix; hip or femur fx or disloc. (%)	49.3	48.9	52.2	49.8	39.8	44.3	39.2	39.0
Physical therapy exercises; manipulation; and other procedures (%)	3.6	3.6	2.9	5.1	3.4	4.0	3.7	3.6
Respiratory Intubation and MV (%)	1.8	1.9	1.4	2.2	1.8	0.8	5.2	3.9

**Supplementary Table 3:** Post-Matching Balance, Hip Fracture

	Always Takers			Compliers			Never Takers		
	IRF <sub>pre</sub>	IRF <sub>post</sub>	Std. Diff.	IRF <sub>pre</sub>	SNF <sub>post</sub>	Std. Diff.	SNF <sub>pre</sub>	SNF <sub>post</sub>	Std. Diff.
N (Weighted)	759	759		1,175	1,175		3,757	3,757	
N (Unweighted)	759	759		1,175	1,300		3,757	4,047	
Age	80.08	79.99	0.92	81.46	80.92	6.36	83.66	83.69	-0.28
Sex: Female (%)	73.52	74.31	-1.81	75.15	73.94	2.81	76.04	73.78	5.30
Race: White (%)	94.20	93.41	3.19	92.51	93.31	-3.04	93.80	91.87	7.98
Race: Black (%)	3.43	3.29	0.74	3.15	1.70	8.28	2.66	3.62	-5.98
Medicaid Dual (%)	10.01	9.88	0.44	17.45	14.65	7.36	27.47	30.02	-5.71
hospital LOS	5.06	5.16	-3.28	5.19	5.28	-3.46	6.09	5.90	4.66
ICU (%)	15.42	17.13	-4.55	20.17	20.58	-1.02	16.88	15.39	3.97
CCU (%)	4.08	6.06	-8.28	4.94	5.45	-2.36	3.86	5.19	-6.93
Elixhauser mortality score	4.88	5.17	-3.66	4.71	4.92	-2.84	6.01	6.31	-3.67
Readmit Score	10.41	11.41	-0.09	11.06	11.35	-2.73	13.07	13.77	-6.34
Count CCW Conditions (N)	9.76	10.35	-17.24	10.62	10.71	-2.73	11.49	11.80	-9.44
Pre Hospit: Nursing Home (%)	0.13	0.40	-4.2	2.38	1.28	7.25	19.30	18.74	1.40
CCW: ADRD (%)	20.29	28.46	-18.1	27.40	28.00	-1.34	54.72	56.93	-4.44
CCW: CHF (%)	37.15	39.92	-5.65	45.96	46.87	-1.82	46.66	46.95	-0.59
CCW: COPD (%)	42.42	40.71	3.49	47.40	47.72	-0.64	53.93	53.26	1.33
CCW: Osteoporosis (%)	45.85	49.67	-7.64	50.38	45.99	8.78	51.26	52.59	-2.64
CCW: Cataracts (%)	76.28	79.05	-6.8	80.43	79.74	1.72	81.42	82.14	-1.84
CCW: Hypertension (%)	89.06	91.30	-7.95	90.98	92.32	-4.69	93.37	94.66	-5.19
CCW: Anemia (%)	83.53	88.27	-14.74	86.55	86.47	0.24	89.67	89.36	1.03
CCW: Depression (%)	23.85	25.56	-3.93	41.79	42.73	-1.91	52.14	53.80	-3.31
CCW: Atrial Fib. (%)	36.63	44.93	-16.69	28.68	29.24	-1.24	30.58	32.94	-5.11
CCW: Chronic Kidney Disease (%)	39.26	44.40	-10.34	35.23	42.66	-15.54	44.45	50.18	-11.53
CCW: Diabetes (%)	33.33	35.05	-3.59	37.36	42.66	-10.95	40.91	41.89	-1.99
CCW: Hyperlipidemia (%)	75.10	78.79	-9.02	80.34	80.73	-0.98	76.36	81.58	-12.28
CCW: Ischemic Heart Disease (%)	60.21	59.68	1.07	67.74	64.85	6.20	68.78	69.98	-2.60
CCW: Stroke/TIA (%)	25.96	24.64	3.06	28.94	29.88	-2.07	32.07	33.07	-2.13
Septicemia (not in labor) (%)	1.19	1.45	-2.2	0.68	0.94	-3.10	1.73	1.36	2.86
Diabetes mellitus with complications (%)	1.98	3.16	-6.78	2.72	3.86	-7.00	2.13	2.69	-3.92
Rheumatoid arthritis and related disease (%)	5.14	5.93	-3.35	3.91	5.61	-8.74	5.08	6.81	-7.86
Other fractures (%)	12.65	18.71	-15.54	8.77	8.87	-0.35	18.66	19.71	-2.69
Acute posthemorrhagic anemia (%)	39.00	39.13	-0.27	30.89	31.47	-1.25	32.45	30.57	4.00
Acute myocardial infarction (%)	1.58	2.11	-3.67	1.28	0.98	2.65	1.41	1.30	0.98
Secondary malignancies (%)	1.58	0.40	18.9	1.45	1.02	3.56	2.02	1.24	5.55

Coronary atherosclerosis and other heart disease (%)	25.03	27.27	-5.03	26.72	27.53	-1.83	27.68	29.49	-4.04
Fracture of neck of femur (%)	86.96	82.08	12.71	90.55	90.16	1.36	80.89	79.88	2.57
Acute unsp. renal failure (%)	2.50	1.45	8.82	2.55	2.23	2.07	4.13	3.58	2.74
Chronic ulcer of skin (%)	9.88	11.86	-6.11	8.51	9.96	-5.18	13.07	12.88	0.57
Nutritional deficiencies (%)	11.46	15.28	-10.62	10.89	16.18	-16.95	11.82	15.57	-11.62
Other nutritional; endocri; & metabolic disorders (%)	5.40	5.93	-2.23	5.79	8.26	-10.57	11.45	10.71	2.31
Respiratory failure; insufficiency; arrest (%)	5.27	6.72	-5.79	5.53	7.65	-9.27	7.69	7.83	-0.51
Phlebitis; thrombophlebitis and thromboembolism (%)	2.64	4.61	-9.42	4.00	3.95	0.25	3.94	4.71	-3.98
Fx tx incl. reposition w/ or w/o fix; hip or femur fx or disloc. (%)	33.60	33.60	0	37.45	38.20	-1.55	28.13	29.91	-3.95
Hip replacement; total and partial (%)	36.36	31.49	10.5	34.89	30.54	9.13	37.50	31.86	11.65
Blood transfusion (%)	54.02	49.80	8.43	53.87	51.91	3.93	49.43	47.63	3.59
Respiratory intubation & mechanical ventilation (%)	1.98	2.90	-5.5	2.04	1.80	1.68	1.54	1.45	0.77
Fracture treatment including reposition with or without fixation (%)	4.48	5.14	-2.98	2.72	3.36	-3.92	3.67	4.94	-6.72
Unmatched ASMD			6.95			13.21			3.42
Matched ASMD			6.76			4.34			4.44
Rubin's B-Statistic			0.06			0.26			0.01
Rubin's R-Statistic			114.47			100.76			100.12

## Covariates associated with increased mortality when patients switched from IRF to SNF following IRF-unit closure

Our 30-days mortality regression included all covariates X and their interactions with the post indicator Post\*X among the Compliers. The coefficients represent the percentage change in the probability of the outcome per one percentage change in X. The coefficients of the Post\*X factors represent the change in mortality risk in the SNF post-IRF closure period vis-à-vis the associated risk of the factor in the IRF baseline period. The regression included hospital fixed effects to adjust for unmeasured hospital factors and was weighted to account for matching with replacement.

**Supplementary Table 4A:** Covariates Associated with Increased 30-day Mortality among Compliers Following IRF-unit Closure, Stroke (N=1,420).

<b>Y= 30-day Mortality (Binomial Yes/No)</b>						
<b>Covariate</b>	<b>Baseline (IRF Care)</b>			<b>Change from Baseline (X*Post)</b>		
	<b>Coeff.</b>	<b>95% CI</b>		<b>Coeff.</b>	<b>95% CI</b>	
Age	0.0	-0.2	0.2	0.2	-0.1	0.5
Sex (female)	-0.6	-4.6	3.4	4.4	-1.4	10.2
Race (black)	-6.6	-14.9	1.6	2.2	-9.4	13.9
Race (other)	-4.6	-11.6	2.5	-3.1	-12.3	6.1
<b>Chronic Conditions Prior to Index Hospitalization</b>						
CCW: ADRD	1.0	-3.3	5.4	1.5	-4.6	7.6
CCW: CHF	-3.1	-7.4	1.2	3.1	-3.0	9.2
CCW: COPD	-1.3	-5.2	2.7	1.4	-4.2	7.1
CCW: Osteoporosis	-1.8	-6.4	2.8	2.3	-4.2	8.9
CCW: Hypertension	-0.9	-9.4	7.6	2.1	-11.0	15.2
CCW: Depression	-0.5	-4.5	3.6	-2.5	-8.2	3.3
CCW: N of Chronic Conditions (0-27)	0.6	-0.2	1.5	-0.3	-1.5	0.9
<b>Index Hospitalization Characteristics</b>						
Stroke type: Hemorrhagic	-2.2	-8.2	3.7	<b>9.5</b>	<b>1.1</b>	<b>18.0</b>
Other nutritional; endocrine; and metabolic disorders	0.1	-5.2	5.3	4.8	-2.2	11.7
Diseases of white blood cells	-1.4	-12.4	9.5	<b>16.6</b>	<b>1.8</b>	<b>31.5</b>
Paralysis	-1.6	-5.5	2.3	3.7	-1.5	8.9
Other nervous system disorders	2.0	-1.7	5.6	-1.5	-6.5	3.6
Other and ill-defined heart disease	-5.6	-18.5	7.4	<b>16.6</b>	<b>0.2</b>	<b>33.1</b>
Transient cerebral ischemia	-7.0	-24.3	10.4	7.0	-15.0	29.0
Gastroduodenal ulcer (except hemorrhage)	-1.2	-20.1	17.7	11.2	-11.6	34.0
Other liver diseases	-6.4	-20.3	7.4	<b>21.2</b>	<b>1.9</b>	<b>40.4</b>
Dysphagia and other gastrointestinal disorders	-2.2	-6.9	2.5	5.8*	-0.7	12.3
Urinary tract infections	1.0	-3.9	5.9	-2.2	-9.2	4.9
Hyperplasia of prostate	0.9	-5.8	7.5	7.6	-2.5	17.6
Other connective tissue disease	-0.7	-4.8	3.4	-0.8	-6.5	4.8
Gastrostomy; temporary and permanent	12.2	1.2	23.2	-8.4	-24.0	7.1
Respiratory intubation and mechanical ventilation	-2.7	-15.4	9.9	14.3	-3.8	32.3
Other therapeutic procedures	-0.1	-8.9	8.8	1.5	-10.5	13.4
ICU (yes/no)	1.2	-2.9	5.2	0.8	-4.5	6.1
Hospitalization LOS (days)	0.3	-0.1	0.8	-0.6	-1.3	0.1

Note: Bold numbers indicate statistically significant at the 5% level, \* = statistically significant at the 10% level.

The regression included additional patient covariates not included in the table due to space limitations and lack of significance.

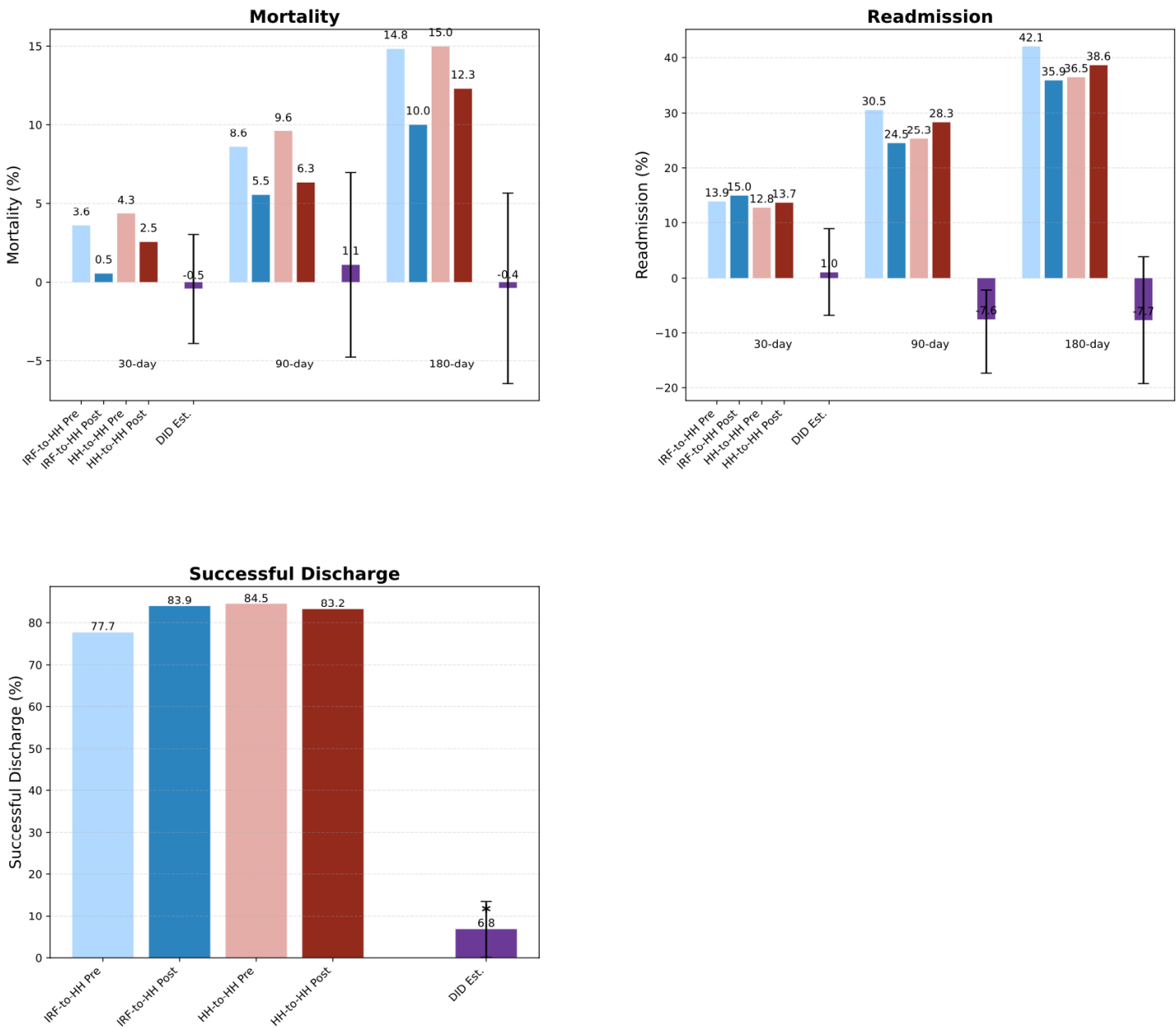
**Supplementary Table 4B:** Covariates Associated with Increased 30-day Mortality among Compliers Following IRF-unit Closure, Hip Fracture (N=2,600)

<b>Y= 30-day Mortality (Binomial Yes/No)</b>	<b>Baseline (IRF Care)</b>			<b>Change from Baseline (X*Post)</b>		
	<b>Coeff.</b>	<b>95% CI</b>		<b>Coeff.</b>	<b>95% CI</b>	
<b>Covariate</b>						
Age	0.0	-0.1	0.1	<b>0.2</b>	0.0	0.5
Sex (female)	-0.7	-2.6	1.2	-0.5	-4.0	2.9
Race (black)	0.4	-4.4	5.2	0.4	-9.8	10.6
Race (other)	0.3	-3.6	4.1	-0.9	-7.5	5.7
<b>Chronic Conditions Prior to Index Hospitalization</b>						
CCW: ADRD	-0.8	-2.7	1.2	1.7	-1.7	5.2
CCW: CHF	2.5	0.6	4.4	-2.2	-5.6	1.3
CCW: COPD	0.1	-1.8	1.9	-0.3	-3.6	2.9
CCW: Osteoporosis	0.6	-1.2	2.4	-1.7	-5.0	1.6
CCW: Hypertension	0.2	-2.6	3.0	1.8	-3.5	7.2
CCW: Atrial Fibrillation	0.6	-1.4	2.5	-4.4	-7.9	-1.0
CCW: Kidney Disease	0.5	-1.6	2.5	0.1	-3.4	3.6
CCW: Depression	-0.2	-2.0	1.6	-1.0	-4.3	2.3
CCW: Diabetes	0.3	-1.4	2.1	2.0	-1.3	5.2
CCW: N of Chronic Conditions (0-27)	-0.1	-0.7	0.5	0.0	-1.1	1.1
<b>Index Hospitalization Characteristics</b>						
Septicemia (except in labor)	-1.0	-10.3	8.4	-0.2	-16.1	15.7
Secondary malignancies	4.5	-2.7	11.7	<b>16.2</b>	<b>2.0</b>	<b>30.4</b>
Fluid and electrolyte disorders	-0.5	-2.7	1.7	<b>5.4</b>	<b>1.5</b>	<b>9.3</b>
Coagulation and hemorrhagic disorders	-3.7	-6.8	-0.6	<b>9.9</b>	<b>4.3</b>	<b>15.4</b>
Parkinson's disease	-2.1	-6.6	2.4	<b>16.8</b>	<b>7.6</b>	<b>26.1</b>
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease)	3.7	-0.9	8.4	<b>12.5</b>	<b>3.4</b>	<b>21.6</b>
Acute myocardial infarction	-1.7	-8.3	4.8	-0.9	-13.9	12.1
Coronary atherosclerosis and other heart disease	0.0	-1.9	1.9	<b>4.4</b>	<b>0.8</b>	<b>7.9</b>
Congestive heart failure; non-hypertensive	-3.1	-5.8	-0.4	4.6*	-0.4	9.6
Pneumonia (except that caused by tb/std)	3.8	0.0	7.5	<b>11.1</b>	<b>4.7</b>	<b>17.6</b>
Aspiration pneumonitis; food/vomitus	-2.8	-12.6	7.1	<b>35.4</b>	<b>21.4</b>	<b>49.5</b>
Respiratory failure; insufficiency; arrest (adult)	0.3	-3.2	3.8	-1.3	-7.3	4.8
Acute and unspecified renal failure	-1.8	-4.7	1.2	<b>8.3</b>	<b>3.2</b>	<b>13.3</b>
Fracture of neck of femur (hip)	0.7	-3.3	4.7	3.0	-4.5	10.5
Other fractures	-0.4	-5.0	4.3	<b>9.0</b>	<b>0.3</b>	<b>17.8</b>
Hip replacement; total and partial	0.8	-2.6	4.2	-2.7	-8.9	3.5
Respiratory intubation and mechanical ventilation	-3.0	-9.9	3.9	-2.1	-14.1	9.9
ICU (yes/no)	-1.1	-3.4	1.1	<b>4.9</b>	<b>1.1</b>	<b>8.6</b>
Hospitalization LOS (days)	0.1	-0.2	0.4	-0.7	-1.2	-0.2

Note: Bold numbers indicate statistically significant at the 5% level, \* = statistically significant at the 10% level. The regression included additional patient covariates not included in the table due to space limitations and lack of significance.

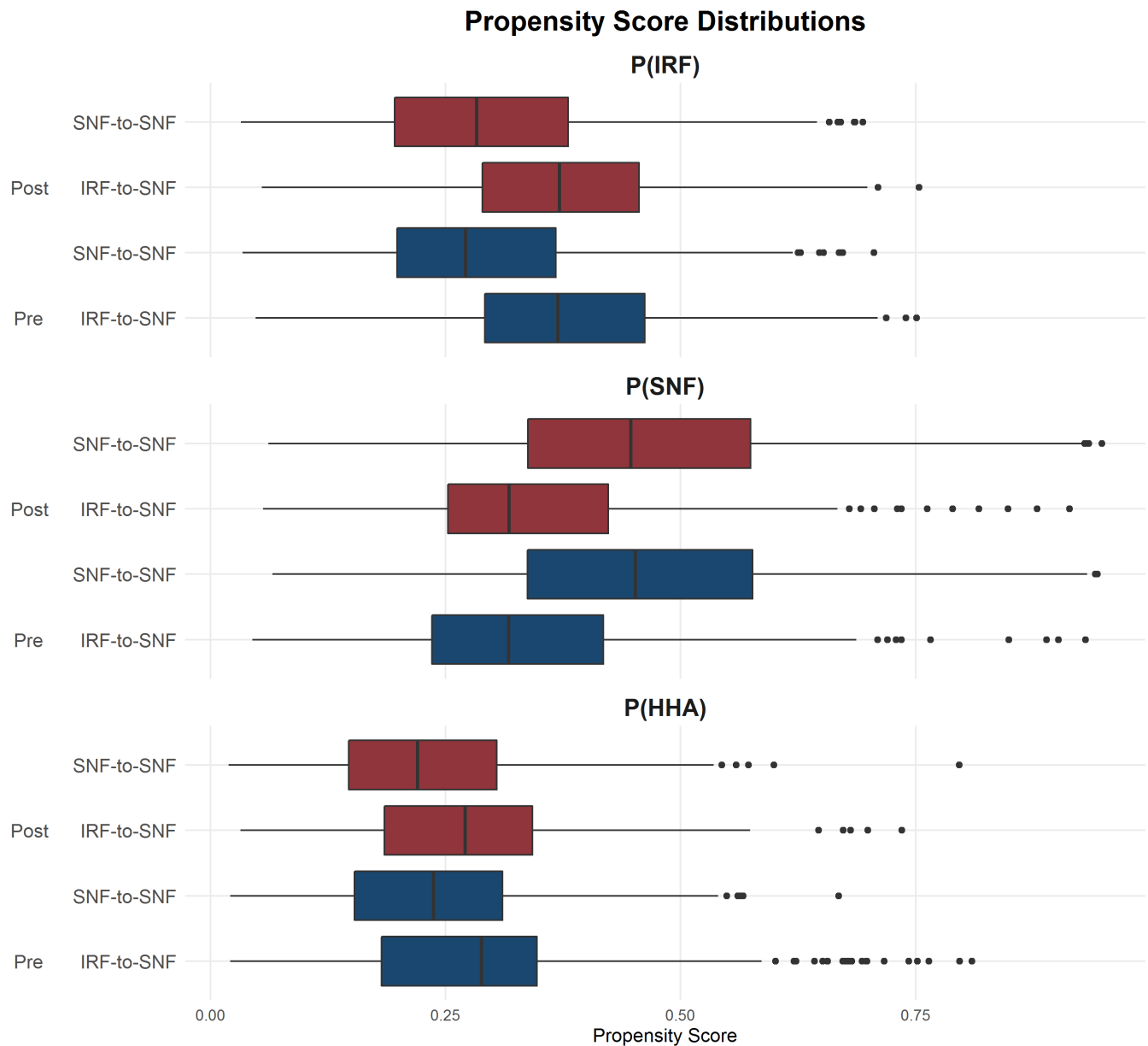
Supplementary Figure 1

IRF vs HH Care Outcomes in Stroke Patients



**Note:** DID =Difference in differences, unadjusted mean values and DID point estimates (bars) and 95% confidence interval (black lines)

## Supplementary Figure 2



**Note:** This plot depicts the distribution of propensity scores used in our matching approach for the IRF vs SNF comparison among stroke patients.

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