Effect of Prospective Payment System on Health Equity in Post-acute Care Among Traditional Medicare Beneficiaries in Inpatient Rehabilitation Facilities

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Abstract: This study investigates the impact of the Medicare Prospective Payment System (PPS) on health equity in post-acute care (PAC) among Traditional Medicare beneficiaries in Inpatient Rehabilitation Facilities (IRFs). Using an instrumental variable (IV) approach, we employ expected length of stay (LOS) as an instrument to assess the causal effects of LOS on various outcomes, including functional improvements, discharge location, and successful return to the community. The analysis leverages data from the Inpatient Rehabilitation Facility-Patient Assessment Instrument (IRF-PAI) for 2019–2020, focusing on key conditions such as stroke, hip fractures, joint replacements, and cardiac issues.

Our results show that a longer LOS is significantly associated with improvements in mobility and cognitive function, as well as a greater likelihood of discharge to home health or Skilled Nursing Facilities (SNF), particularly for stroke and hip fracture patients. For stroke patients, in particular, the PPS-regulated LOS adjustments positively influence functional recovery and discharge outcomes, suggesting that extending LOS can mitigate disparities and promote health equity in PAC settings. These findings highlight the role of PPS as a policy lever for optimizing PAC delivery, thereby supporting equitable care and enhancing recovery outcomes for vulnerable populations in IRFs.

Introduction

Post-acute care (PAC) is an essential component in the continuum of health care services. It provides tailored support for patients recovering from acute illness or injuries. By 2021, Traditional Medicare (TM) spending on PAC had doubled compared to 2001, which reached $56.8 billion.[1,2] Inpatient rehabilitation facilities (IRFs) provide the most intensive care rehabilitation care comparing to other PAC facility types such as skilled nursing facilities (SNFs) and home health agencies (HHAs). The TM expenditure for IRF also experienced a substantial increase, from $4.8 billion in 2001 to $8.8 billion by 2021.[1,2] This sharp increase in spending reflects the critical role of IRF in supporting the health and recovery of TM beneficiaries.

Medicare, which is administrated by the Centers for Medicare & Medicaid Services (CMS), is the primary payer for PAC. It offers two coverage types: Traditional Medicare (TM) (Part A and B) and Medicare Advantage (MA) (Part C). TM is a fee-for-service plan centrally administered by CMS, and MA plans are capitated plans individually managed by various insurance providers.[3]

At the beginning, IRFs received payments based on a cost-reimbursement model, subject to per-patient limits that varied widely across facilities. These limits were established based on each facility's historical costs, calculated as the average cost per patient during the facility's base year of operation.[4] However, this method proved ineffective in controlling healthcare costs within IRFs. Notably, between 1988 and 1997, post-acute care emerged as the fastest-growing category of Medicare expenditure, experiencing an average annual growth rate of 25%.[5] The Balanced Budget Act of 1997 and subsequent Balanced Budget Refinement Act of 1999 attempted to control the rising spending and costs by shifting payments to providers from a cost basis to prospective payment systems (PPSs). The Medicare Prospective Payment System (PPS) was implemented in Inpatient Rehabilitation Facilities (IRFs) in January 2002. This system reimburses IRFs based on a combination of the patient's case mix groups (CMGs) and comorbidity tier (Tier)—determined by the primary reason for rehabilitation, functional status, age, and number and severity of comorbidities—and factors related to the provider, such as the wage index and other characteristics. Additionally, adjustments are made for rural status, the proportion of low-income patients, and the presence of short-stay and high-cost outliers, ensuring a more nuanced and equitable reimbursement structure.

Research has demonstrated that the IRF PPS is an effective mechanism that has significantly reduced both costs and the LOS without negatively affecting health outcomes.[6,7]

Under the IRF PPS, the reimbursement rates are not static. The Centers for Medicare & Medicaid Services (CMS) annually adjusts these rates to account for changes in various factors, including wage inflation as well as variation in utilization by CMG and Tier during the previous five years across the country. Many research has investigated the policy effects in the early stage of PPS implementation.[6,8-11] However, there is scant research exploring whether these annual adjustments have effects on LOS, and therefore affect care delivery and outcomes of Post-Acute Care (PAC) within IRFs.

Based on the above literature review, this study aims to explore the consequences of PPS modifications on LOS. We hypothesize that PPS annually modification would subsequently change various post-acute care outcomes for traditional Medicare beneficiaries. Specifically, we primarily focus on patients with four conditions: stroke, hip fracture, cardiac, and joint replacement. These conditions are the most common conditions for IRFs, which have been studied by other studies.[12] This investigation aims to shed light on how changes in the PPS influence LOS. In turn, variations in LOS affect patient care and outcomes across different demographic and clinical groups over time.

Theoretical Framework

In this section, we build an economic model for how different factors influence the LOS in IRFs and whether these factors lead to health inequities among TM beneficiaries. We also used this model to identify whether the PPS can reduce health inequities among TM beneficiaries.

Under TM, IRFs are paid via the Prospective Payment System (PPS). This means they receive a fixed payment based on the expected LOS for a given patient type (CMGs Group and Tiers). The profit function for taking care of a single patient among TM beneficiaries can be written as:

$$\pi = P - C \ (1.1)$$

P is the reimbursement level pre-determined by the PPS, and C is the actual cost during the treatment process.

To simplify our model, the actual costs we assume to be associated with the actual LOS of a single patient staying in the hospital. Thus, we define:

$$C = C\left({LOS_{TM\ actual}}^2\right)(1.2)$$

$LOS_{TM\ actual}$ measures the number of LOS a single patient stays in IRFs during the treatment process. The square of $LOS_{TM\ actual}$ captures the increasing marginal costs associated with longer stays, according to Grossman model of health demand.[13]

When a single patient is admitted into IRFs, the PPS will pre-determine an expected LOS as the reference for IRFs. If the actual LOS is larger than the expected LOS, IRFs will lose the profit, vice versa. Moreover, the reimbursement level P is also associated with expected LOS. Thus, both P and $LOS_{TM\ actual}$ can be defined as a function of $LOS_{TM\ expected}$ as:

$$P = pLOS_{TM\ expected}\ (1.3)$$

$$LOS_{TM\ actual} = f\left(LOS_{TM\ expected}, \theta\right)\ (1.4)$$

p is the predetermined payment rate for one unit of LOS. θ captures the effect from all other non-clinical factors. If $\theta = 0$, $LOS_{TM\ actual}$=$LOS_{TM\ expected}$, so there is no health equity issue. If $\theta > 0$, $LOS_{TM\ actual} \neq LOS_{TM\ expected}$. There is a health equity issue.

If we include equation (2) (3) (4) into equation (1.1), the profit function for TM is defined as:

$$\pi = pf\left(LOS_{TM\ expected}, \theta\right) - C\left(f^2\left(LOS_{TM\ expected}, \theta\right)\right)\ (1.5)$$

To maximize the profit, I take the first order condition of Equation (5) with respect to $LOS_{TM\ expected}$:

$$\frac{d\pi_{TM}(t)}{dLOS_{TM\ expected}} = p\frac{df}{dLOS_{TM\ expected}} - \frac{dC}{df^2}\frac{df^2}{df}\frac{df}{dLOS_{TM\ expected}} = 0\ (1.6)$$

Then, we can get:

$$p\frac{df}{dLOS_{TM\ expected}} = 2f\frac{dC}{df^2}\frac{df}{dLOS_{TM\ expected}}\ (1.7)$$

If we assume that equation (1.4) is linear, $\frac{df}{dLOS_{TM\ expected}}$, will be a constant which measures the marginal effect of expected LOS on actual LOS. Since equation (1.4) is linear, we can get $C(f^2)$ is quadratic, and $\frac{dC}{df^2}$ is also constant. For example, $C = c_0 + c_1 \cdot f^2$, then $\frac{dC}{df^2} = c_1$. Since both $\frac{df}{dLOS_{TM\ expected}}$ and $\frac{dC}{df^2}\frac{df}{dLOS_{TM\ expected}}$ will be constant, we can get:

$$p = 2f\left(LOS_{TM\ expected}, \theta\right) \times \frac{dC}{df^2} = 2f\left(LOS_{TM\ expected}, \theta\right) \times \alpha\ (\alpha\ is\ constant)(1.8)$$

Then we can get:

$$\frac{p}{2\alpha} = f\left(LOS_{TM\ expected}, \theta\right) \ (1.9)$$

Invert the function of f, we can get:

$$\theta = f^{-1}\left(LOS_{TM\ expected}, \frac{p}{2\alpha}\right) \ (1.10)$$

Thus, the effect from all other non-clinical factors can be a function of expected LOS and the payment rate of PPS.

Methods

Data and Sample

We analyzed data from the Inpatient Rehabilitation Facility—Patient Assessment Instrument (IRF-PAI), which is provided by the Uniform Data System for Medical Rehabilitation (UDSMR) from 2019-2020.[14] The study sample in this study only includes TM beneficiaries of the study sample described in Chapter 1. The UDSMR has the world's largest independent repository of rehabilitation outcomes and IRF-PAI data. The IRF-PAI is mandated by the Centers for Medicare & Medicaid Services (CMS) for reimbursement purposes. It includes comprehensive information on patient demographics, pre-admission and post-discharge locations, medical conditions, facility characteristics, and cost factors like LOS, payment amounts, and sources of payment (e.g., TM and MA). In terms of medical conditions, we include the case-mix group (CMG) and the comorbidity tier. A CMG is a classification system used in inpatient rehabilitation facilities (IRFs) to categorize patients based on their clinical characteristics and resource needs. A comorbidity tier is a classification used in IRFs to account for the presence and severity of additional medical conditions (comorbidities) that a patient may have alongside their primary reason for rehabilitation. Additionally, the IRF-PAI captures patient functionality—assessed within 72 hours of admission and before discharge—as well as details on therapy received, care interruptions, and other key clinical practices.

Our study sample comprises patients aged 65 years and older who were admitted to Inpatient Rehabilitation Facilities (IRFs) for inpatient rehabilitation services. The period of study spans from January 1, 2019, to December 31, 2020, focusing on three common admission conditions prevalent among the aging population: Stroke (Impairment Group Code (IGC): 01.1-01.9), Hip Fracture (IGC: 08.11-08.12), Joint Replacement (IGC: 08.51-08.52, 08.61-08.62, 08.71-08.72), and Cardiac (IGC: 09). The analysis will be conducted separately for each admission condition. Excluded from the sample were those patients who were not admitted for initial rehabilitation or died during the rehabilitation stay, whose prehospitalization living settings were non-home, whose LOSs were longer than 30 days or shorter than 3 days, whose rehabilitation programs were interrupted, or who were discharged against medical advice. These patient-episodes were deemed to be different from others due to complicated clinical concerns and hence were less comparable.[15,16] Figure 1 shows the flowchart of sample derivation and the number of excluded episodes in each step. The final study sample has 184,202 patient episodes, among which 85,737 are stroke, 54,763 are hip fracture, 28,151 are cardiac, and 15,551 are joint replacement.

Variables

In this study, our outcomes include functional improvements, discharge location, and whether the patient has successfully returned to the community. Functional improvements are measured by GC130 (Mobility score improvement) and GC170 (Cognitive score improvement), which are defined by the CMS functional assessment rules introduced in 2019. The discharge Location is a quaternary variable indicating whether the patient is discharged home with self-care, home with home health services, to a Skilled Nursing Facility (SNF), or other locations. Successfully Return to Community After Discharge is a binary variable indicating whether a patient was discharged home, with or without home health care (Yes = 1), or to any other location (No = 0).

Several studies have identified a link between LOS and treatment effects, whether positive or negative.9-11 Thus, we have to select variables that can fully or partially capture the treatment effect. Therefore, we selected these variables because they reflect the health improvements that a patient experiences during their period of PAC in IRFs.

Analytical approach

Empirical analysis

There is a potential issue of endogeneity of LOS, we next implement the instrument variables approach in our analysis. As previously mentioned, an IRF receives a pre-determined prospective payment for each admitted patient based on their Case Mix Groups (CMGs) and comorbidity tier (Tier). Each patient has an expected Length of Stay (LOS) that reflects the anticipated resource utilization for patients within that category.[17] Therefore, the actual LOS is closely related to the expected LOS, which is determined solely by CMGs and comorbidity tiers. As a result of it, the expected LOS serves as an ideal instrumental variable for the actual LOS at the patient-episode level. Moreover, expected LOS will be adjusted by CMS annually each year.

Thus, it is an ideal situation to test whether outcomes will change in response to changes in LOS, which in turn result from changes in expected LOS attributable to CMS policy adjustments.

The following are the empirical two-way fixed-effect instrumental variable models (TWFE IV) I will use:

(1.1) $LOS_{itr} = \alpha_1 Expected\ LOS_{itr} + \alpha_2 X_{itr} + \gamma_{itr} + \tau_{itr} + v_{itr}$ (Stage 1)

(1.2) $Outcome_{itr} = \beta_1 LOS_{itr} + \hat{v}_{itr} + \gamma_2 X_{itr} + \gamma_{itr} + \tau_{itr} + \varepsilon_{itr}$ (Stage 2)

Where the outcome variables are functional improvements, discharge location, and whether the patient has successfully returned to the community of patient i in the administration region r in year-month t, as I mentioned before. γ_{itr} denotes regional fixed effect, which is consistent with 10 CMS administration regions. CMS has 10 regional offices: Boston, New York, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco, and Seattle. τ_{itr} denotes calendar year-month fixed effects. Model (1.1) shows the first stage of IV regression model. Since LOS is a count variable, the poison regression model is used in stage 1. Since our first stage is a non-linear regression model, the predicted LOS in the model (1.1) (first stage) cannot be used in the second stage, or we will get the forbidden regression. To avoid this, we will include the predicted residual $\hat{v}_i$ from model (1.1) (first stage) into model (1.2) (second stage) to estimate the causal effect β_1 of LOS on outcomes. Moreover, since there is a collinearity between expected LOS and CMGs and Tiers, we did not include CMGs and Tiers in the first stage to get the predicted residual v̂. We assume that the expected LOS can cover all the variation from CMGs and Tiers.

Sensitivity analysis

Based on different outcomes, different models in stage 2 were used. Linear regressions were used in mobility score improvement and cognitive score improvement, because all their distribution were normally distributed. As for discharge location, multinomial logistic regression and multinomial probit regression were used to compare the difference of the results as the sensitivity analysis. Regarding successfully returning to community after discharge, logistic regression, linear probability regression and probit regression were used to conduct the sensitivity analysis.

Results

Descriptive statistics

Figure 2 showed mobility and cognitive score improvement over months of patients among traditional Medicare Beneficiaries by different conditions. Both mobility score improvement and cognitive score improvement is constant over time among stroke, fracture, and cardiac patients. Among joint replacement patients, the cognitive score improvement shows a sharp decrease at the beginning of pandemic but later comes back.

Tables 1-1 to 1-4 present the descriptive statistics across different conditions. There are minimal differences in demographic characteristics across these groups. Among the conditions, hip fracture patients are the oldest, with an average age of around 80, while joint replacement patients are the youngest, with an average age of about 76. The percentage of female patients is higher than that of males for stroke, hip fracture, and joint replacement cases, whereas the cardiac group has a higher percentage of male patients. Hip fracture patients have the highest percentage of white individuals, while stroke patients have the lowest percentage of white individuals across conditions. Stroke patients show a nearly equal distribution between those with and without a partner, while hip fracture, cardiac, and joint replacement patients have a significantly higher percentage of individuals without a partner.

Functional improvements

Table 2-1 to Table 2-4 displays the results from the instrumental variable (IV) regression analysis for mobility and cognitive score improvement by different conditions. As for stroke patients, in the first stage, the expected LOS is significantly associated with actual LOS, with a coefficient of 0.0564 (SE: 0.0002, $p < 0.01$). The incident rate ratio (IRR) for expected LOS is 1.0581 (SE: 0.0003, $p < 0.01$), indicating that a 1-unit increase in expected LOS is associated with a 5.81% increase in the predicted LOS. The second stage of the model shows that a LOS is significantly associated with a 4.51% increase in mobility score (Coefficient: 0.440, SE: 0.018, $p < 0.01$) and a 3.70% increase in cognitive score (Coefficient: 0.898, SE: 0.039, $p < 0.01$).

As for hip fracture patients, in the first stage, the expected LOS is significantly associated with actual LOS, with a coefficient of 0.0582 (SE: 0.0002, $p < 0.01$). The incident rate ratio (IRR) for expected LOS is 1.0600 (SE: 0.0003, $p < 0.01$), indicating that a 1-unit increase in expected LOS is associated with a 6.00% increase in the predicted LOS. The second stage of the model shows that a LOS is significantly associated with a 4.50% increase in mobility score (Coefficient: 0.567, SE: 0.094, $p < 0.01$) and a 2.96% increase in cognitive score (Coefficient: 0.943, SE: 0.210, $p < 0.01$).

As for cardiac patients, in the first stage, the expected LOS is significantly associated with actual LOS, with a coefficient of 0.0669 (SE: 0.0008, $p < 0.01$). The incident rate ratio (IRR) for expected LOS is 1.0692 (SE: 0.0008, $p < 0.01$), indicating that a 1-unit increase in expected LOS is associated with a 6.92% increase in the predicted LOS. The second stage of the model shows that an LOS is significantly associated with a 4.39% increase in mobility score (Coefficient: 0.475, SE: 0.149, $p < 0.01$) and a 3.16% increase in cognitive score (Coefficient: 0.832, SE: 0.309, $p < 0.01$).

As for joint replacement patients, in the first stage, the expected LOS is significantly associated with actual LOS, with a coefficient of 0.0793 (SE: 0.0013, $p < 0.01$). The incident rate ratio (IRR) for expected LOS is 1.0825 (SE: 0.0014, $p < 0.01$), indicating that a 1-unit increase in expected LOS is associated with a 8.25% increase in the predicted LOS. The second stage of the model shows that LOS is not significantly associated with mobility score improvement (Coefficient: 0.089, SE: 0.1, $p > 0.1$). However, LOS is significantly associated with a 3.16% increase in cognitive score (Coefficient: 0.493, SE: 0.230, $p < 0.01$).

The discharge location

Table 3-1 to Table 3-4 displays the IV analysis results for the discharge location, which highlights trends between discharge destination and LOS. As for stroke patients, both the multinomial logistic and probit regressions show consistent patterns. I set discharge to home (self-care) as the reference group. For discharge to home health, the relative risk ratio (RRR) in the multinomial logistic regression is 1.051 ($p < 0.01$), and the coefficient in the multinomial probit regression is 0.037 ($p < 0.01$). This indicates that a longer LOS is associated with a slightly increased likelihood of discharge to home health compared to home. For discharge to a skilled nursing facility (SNF), the RRR is 1.069 ($p < 0.01$), and the probit coefficient is 0.043 ($p < 0.01$), showing a stronger association with longer LOS. Patients with longer LOS are more likely to be discharged to SNF compared to both home and home health. Moreover, the RRR for SNF (1.069) is higher than for home health (1.051), indicating that patients who stay longer are more likely to require discharge to SNFs, which provide more intensive healthcare services. For other discharge locations, the RRR of 0.809 ($p < 0.01$) and a negative /probit coefficient of -0.127 ($p < 0.01$) suggest that longer LOS is associated with a lower likelihood of discharge to other less common locations compared to home.

As for hip fracture patients, both the multinomial logistic and probit regressions show consistent patterns. I set discharge to home (self-care) as the reference group. For discharge to home health, the relative risk ratio (RRR) in the multinomial logistic regression is 1.018 ($p > 0.1$), and the coefficient in the multinomial probit regression is 0.006 ($p > 0.1$). This insignificant association indicates that a longer LOS is not associated with the likelihood of being discharged to home health compared to home. For discharge to a skilled nursing facility (SNF), the RRR is 0.956 ($p > 0.1$), and the probit coefficient is -0.012 ($p > 0.1$), which is not significant. It suggests that LOS is not associated with the likelihood of being discharged to home health. For other discharge locations, the RRR of 0.809 ($p < 0.01$) and a negative /probit coefficient of -0.127 ($p < 0.01$) suggest that longer LOS is associated with a lower likelihood of discharge to other less common locations compared to home.

As for cardiac patients, both the multinomial logistic and probit regressions show consistent patterns. I set discharge to home (self-care) as the reference group. For discharge to home health, the relative risk ratio (RRR) in the multinomial logistic regression is 0.921 ($p > 0.1$), and the coefficient in the multinomial probit regression is -0.080 ($p < 0.05$). This indicates that a longer LOS is associated with a slightly decreased likelihood of discharge to home health compared to home. For discharge to a skilled nursing facility (SNF), the RRR is 1.051 ($p > 0.1$), and the probit coefficient is 0.019 ($p > 0.1$), which is not significant. Patients with longer LOS are not associated with the likelihood of being discharged to SNF. For other discharge locations, the RRR of 0.731 ($p < 0.01$) and a negative /probit coefficient of -0.176 ($p < 0.01$) suggest that longer LOS is associated with a lower likelihood of discharge to other less common locations compared to home.

As for cardiac patients, both the multinomial logistic and probit regressions show consistent patterns. I set discharge to home (self-care) as the reference group. For discharge to home health, the relative risk ratio (RRR) in the multinomial logistic regression is 1.065 ($p < 0.1$), and the coefficient in the multinomial probit regression is 0.044 ($p < 0.1$). This indicates that a longer LOS is not associated with the likelihood of discharge to home health compared to home. For discharge to a skilled nursing facility (SNF), the RRR is 1.117 ($p < 0.1$), and the probit coefficient is 0.071 ($p < 0.1$), which is not significant. Patients with longer LOS are not associated with the likelihood of being discharged to SNF. For other discharge locations, the RRR of 0.931 ($p > 0.1$) and a negative /probit coefficient of -0.016 ($p > 0.1$) suggest that longer LOS is not associated with the likelihood of being discharged to other less common locations compared to home.

Successfully returning to the community after discharge

Table 4-1 to Table 4-4 presents the IV analysis results for returning to the community after discharge. As for stroke patients, logistic regression, linear probability regression, and probit regression models show consistent results regarding the relationship between LOS and the likelihood of returning to the community. In the logistic regression, the odds ratio (OR) for returning to the community is 1.073 (SE: 0.006, $p < 0.01$), indicating that a longer LOS is associated with a higher odd of returning to the community compared to those with shorter stays. The linear probability model shows a similar trend, with a coefficient of 0.016 (SE: 0.001, $p < 0.01$), suggesting that the longer LOS increases the probability of a successful return to the community by 1.6 percentage points. The probit regression further supports this finding with a coefficient of 0.042 (SE: 0.003, $p < 0.01$), confirming that longer LOS positively influences the likelihood of a return to community life.

As for hip fracture patients, logistic regression, linear probability regression, and probit regression models show consistent results regarding the relationship between LOS and the likelihood of returning to the community. In the logistic regression, the odds ratio (OR) for returning to the community is 1.199 (SE: 0.037, $p < 0.01$), indicating that a longer LOS is associated with a higher odd of returning to the community compared to those with shorter stays. However, the linear probability model shows a similar trend, with a coefficient of 0.0005 (SE: 0.005, $p > 0.1$), which suggests that the longer LOS is not associated with the probability of a successful return to the community. The probit regression further supports the finding of the logistic regression with a coefficient of 0.082 (SE: 0.018, $p < 0.01$), which confirms that longer LOS positively influences the likelihood of a return to community life.

As for cardiac patients, logistic regression, linear probability regression, and probit regression models do not show consistent results regarding the relationship between LOS and the likelihood of returning to the community. In the logistic regression, the odds ratio (OR) for returning to the community is 1.095 (SE: 0.045, $p < 0.01$), indicating that a longer LOS is associated with a higher odd of returning to the community compared to those with shorter stays. However, the linear probability model shows a different trend, with a coefficient of -0.0011 (SE: 0.005, $p > 0.1$), which suggests that the longer LOS is not associated with the probability of a successful return to the community. The probit regression shows that LOS is not associated with the likelihood of a return to the community with a coefficient of 0.036 (SE: 0.023, $p > 0.1$), either.

As for joint replacement patients, logistic regression, linear probability regression, and probit regression models consistent results. All suggest that LOS is not associated with the likelihood of successfully returning to the community. In the logistic regression, the odds ratio (OR) for returning to the community is 1.012 (SE: 0.046, $p > 0.1$). The linear probability model shows a similar trend, with a coefficient of 0.0016 (SE: 0.0045, $p > 0.1$). The probit regression shows that LOS is not associated with the likelihood of a return to the community with a coefficient of 0.003 (SE: 0.024, $p > 0.1$), either.

Discussion and Limitation

My findings highlight the causal effect between length of stay (LOS) and various post-acute care (PAC) outcomes in inpatient rehabilitation facilities (IRFs). The association between LOS and expected LOS is statistically significant across all patient conditions. However, when expected LOS is used as an instrumental variable, the strength and significance of the association between LOS and different discharge outcomes vary by condition.

In general, our results suggest the strongest association between LOS and outcomes among stroke patients. All outcomes are significantly associated with LOS. There is a positive and significant relationship between LOS and improvements in both mobility and cognitive function. Additionally, longer LOS is linked to a higher likelihood of successful community reintegration upon discharge, suggesting that extended stays support better recovery and health outcomes. Extended rehabilitation appears to facilitate sufficient recovery, enabling patients to reintegrate into their communities. Thus, longer LOS is generally associated with better health improvement, which is supported by other studies.[18,19] However, the results are not consistent with studies in other PAC settings, which show SNF stays may be unnecessarily long.[20] Our results also suggest that SNF discharges have higher relative risk ratios (RRR) and coefficients compared to home health. This can be explained that the longer LOS reflects greater healthcare needs. Patients will be discharged to other settings after their health status reaches the benchmark. Longer LOS of patients are thought to be associated with higher-order impairments. These individuals may still require more intensive PAC support because of ongoing functional limitations or recovery hurdles compared to patients with less impairments. This finding aligns with evidence from numerous other studies.[19,21-23]

For patients with hip fractures, a positive and significant relationship exists between LOS and improvements in mobility and cognitive function. However, LOS does not significantly influence discharge location, specifically SNF or home health. Nonetheless, longer LOS remains associated with a higher likelihood of successful community discharge (OR=1.199, $p<0.01$), indicating that extended stays contribute to improved recovery and health outcomes for this population as well. For cardiac patients, LOS is positively associated with mobility and cognitive improvements, but the effect size is small (RRR=0.921, $p<0.1$), and no significant relationship is observed between LOS and discharge locations of home or home health. However, longer LOS still corresponds to an increased likelihood of returning to the community after discharge (OR=1.095, $p<0.05$). This suggests that even modestly extended stays may enhance recovery and post-discharge outcomes, supporting reintegration into the community. In contrast, for patients undergoing joint replacement, LOS is positively associated with cognitive improvements, but not with mobility gains. Additionally, LOS does not significantly influence discharge location or the likelihood of successful community return, indicating that extended stays may not provide meaningful benefits for recovery and health outcomes in this patient group.

The differences can be explained by stroke patients usually require the highest tailored rehabilitation to address specific impairments.[24,25] Thus, extended LOS significantly impacts both their functional recovery and discharge planning, and directly influences their ability to transition to less intensive settings. Compared to stoke patients, hip fracture and cardiac patients generally require rehabilitation to regain independence and stability but often reach a functional level that enables them to avoid high-level care settings like SNFs.[19,21,26,27] Longer stays enhance their readiness for community discharge without necessarily shifting the discharge setting. Thus, extended LOS for hip fracture and cardiac patients supports functional gains, which make them more likely to transition directly to community living. However, LOS doesn't strongly impact discharge location because they typically do not require high-level care beyond IRF when they achieve a stable state. Unlike stroke or hip fracture patients, joint replacement patients often regain mobility relatively quickly, requiring less intensive or prolonged rehabilitation. This population may not benefit from extended stays because their needs are met within a shorter time frame. Moreover, for joint replacement patients, the elective and selective nature of the procedure makes LOS less dependent on clinical recovery needs and more influenced by individual patient factors.[28-30] These lead to a lack of significant association between LOS and recovery outcomes.

There are several limitations to this study. First, since our dataset is national in scope, the results may not be valid for state or county-level analyses. Second, the study may not fully account for other policy changes during the study period, which could independently affect LOS and discharge outcomes. The reliance on administrative data, which may contain inaccuracies or misclassifications, could affect the measurement of key variables. Third, the study's focus on specific conditions such as strokes, hip fractures, cardiac, and joint replacements may limit the generalizability of the findings to other conditions treated in IRFs. Fourth, the impact of the COVID-19 pandemic, which significantly altered healthcare delivery and IRF operations, adds another layer of complexity to the interpretation of results. Finally, the study focuses on outcomes measured within a relatively short follow-up period (2019-2020). Long-term outcomes and sustainability of the observed effects are not assessed, limiting the understanding of the long-term impact of PPS adjustments.

Conclusion

Using expected LOS as an instrumental variable, LOS is significantly associated with various outcomes in PAC within IRFs. The strength of this association varies across conditions, with stroke patients showing the strongest significance. These findings suggest that the PPS can effectively reduce health disparities and promote health equity, with stroke patients benefiting the most from this approach.

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Figure 1: Flow Chart

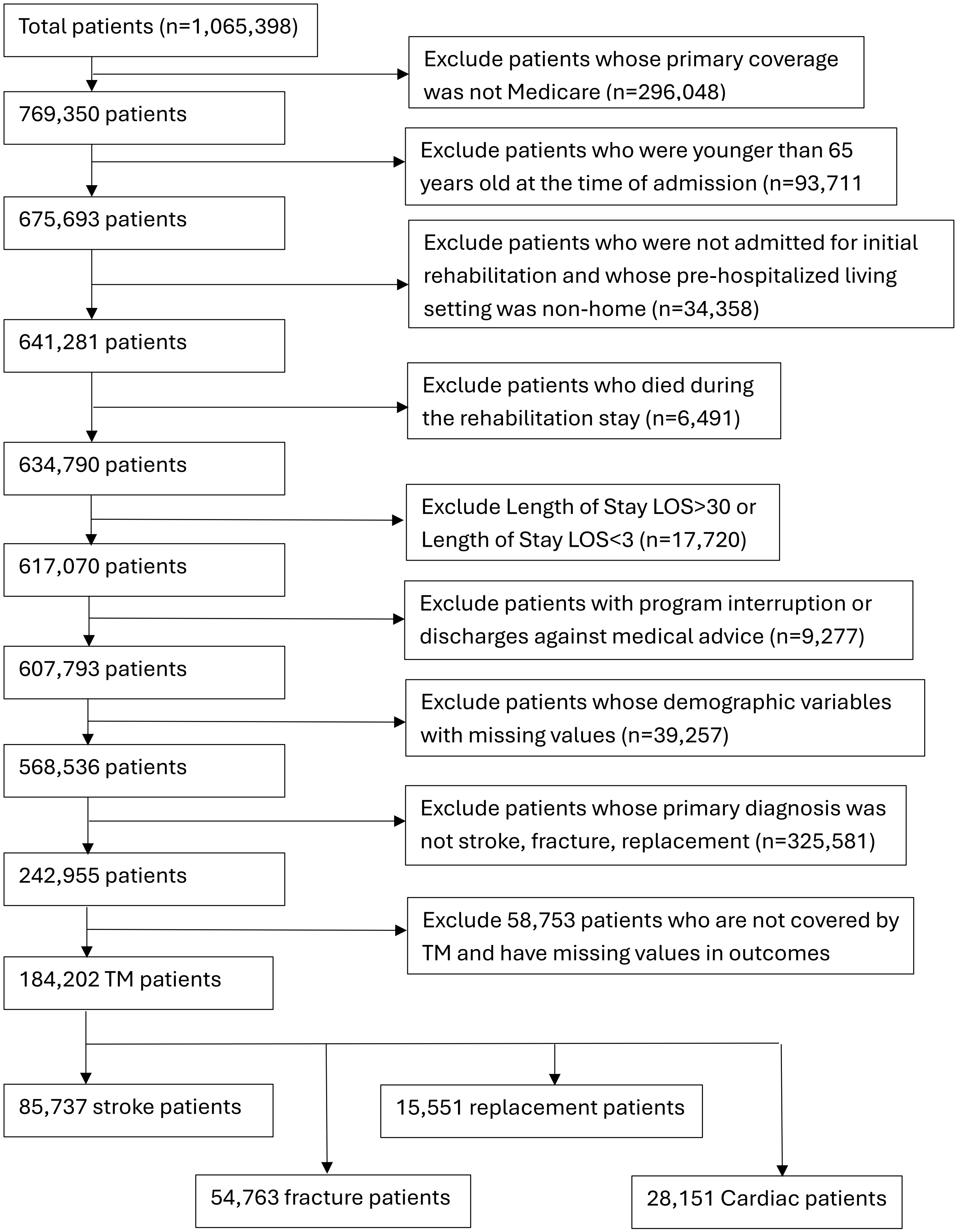

Figure 2: Mobility score and cognitive score by diseases over months

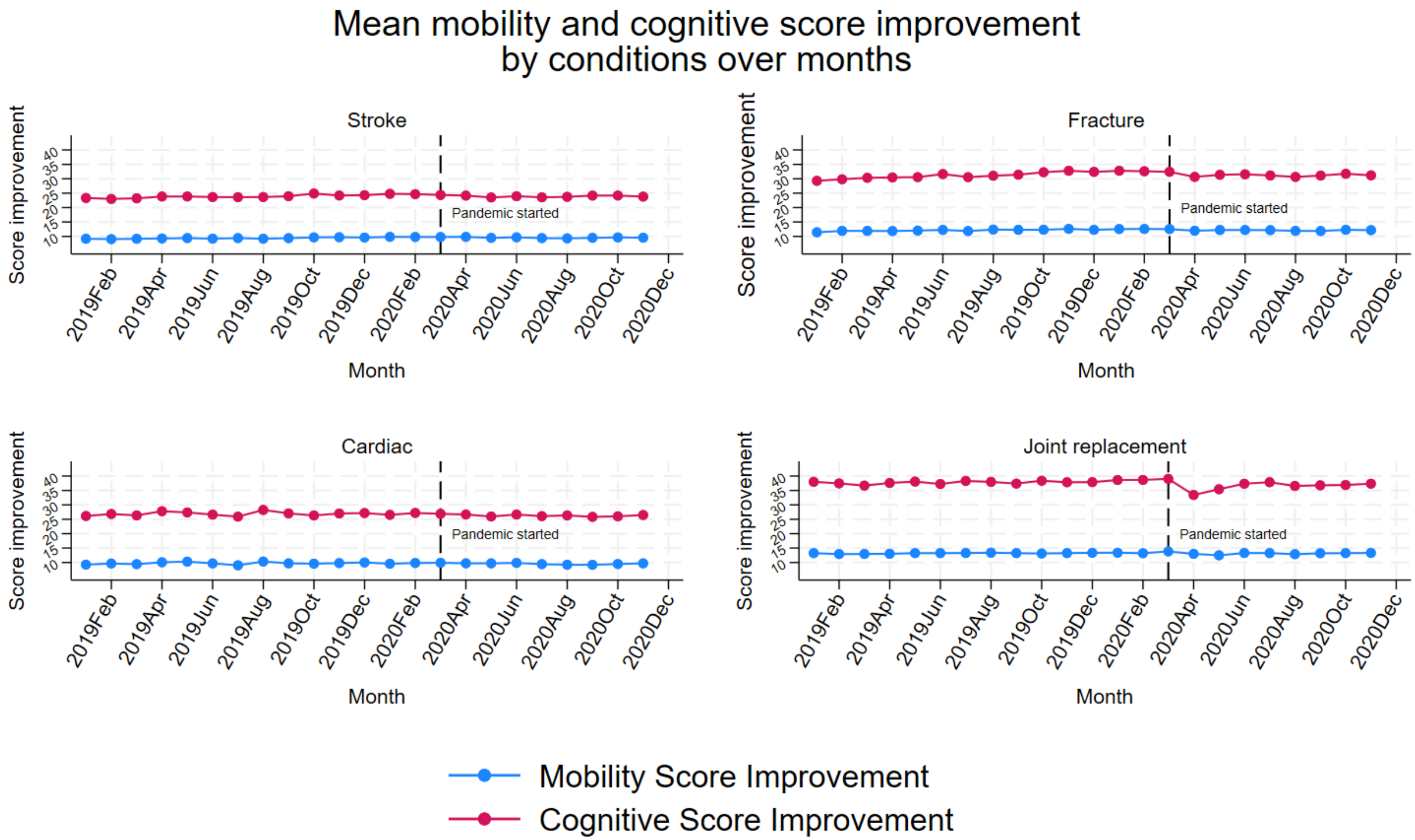

Table 1-1: Descriptive statistics of stroke patients among traditional Medicare beneficiaries

TM N=85,737	Pre-pandemic Mean	N=53,789 SD	During-pandemic Mean	N=31,948 SD
Age	77.33	0.03	77.29	0.04
Certified Beds	48.52	0.15	48.73	0.19
	N	**%**	**N**	**%**
Gender				
Male	26,182	48.68	15,663	49.03
Female	27,607	51.32	16,285	50.97
Race				
NH White	43,863	81.55	26,422	82.7
NH Black	5,969	11.1	3,321	10.4
Hispanic	2,209	4.11	1,169	3.66
Other	1,748	3.25	1,036	3.24
Marital Status				
With a partner	26,963	50.13	15,956	49.94
Without a partner	26,826	49.87	15,992	50.06
Dual Coverage				
No	49,203	91.47	29,269	91.61
Yes	4,586	8.53	2,679	8.39
CMG				
101	3,786	7.04	1,676	5.25
102	8,182	15.21	4,189	13.11
103	14,988	27.86	8,204	25.68
104	9,283	17.26	5,630	17.62
105	4,032	7.5	2,798	8.76
106	13,518	25.13	9,451	29.58
Tier				
None	28,553	53.08	15,965	49.97
Major	1,199	2.23	769	2.41
Medium	677	1.26	474	1.48
Minor	23,360	43.43	14,740	46.14
Facility type				
Freestanding	30,096	55.95	17,616	55.14
Unit in hospital	23,693	44.05	14,332	44.86
Region				
P01	3,107	5.78	1,835	5.74
P02	2,805	5.21	1,575	4.93
P03	6,594	12.26	4,185	13.1
P04	11,840	22.01	6,901	21.6
P05	7,854	14.6	4,505	14.1
P06	9,009	16.75	5,404	16.91
P07	3,305	6.14	1,994	6.24
P08	1,809	3.36	1,197	3.75
P09	5,793	10.77	3,304	10.34
P10	1,673	3.11	1,048	3.28

Table 1-2: Descriptive statistics of hip fracture patients among traditional Medicare beneficiaries

TM N=54,763	Pre-pandemic Mean	N=31,817 SD	During-pandemic Mean	N=22,946 SD
Age	80.25	0.04	80.46	0.05
Certified Beds	47.77	0.19	47.10	0.22
	N	**%**	**N**	**%**
Gender				
Male	9,694	30.47	7,008	30.54
Female	22,123	69.53	15,938	69.46
Race				
NH White	29,099	91.46	21,160	92.22
NH Black	944	2.97	680	2.96
Hispanic	1,122	3.53	665	2.90
Other	652	2.05	441	1.92
Marital Status				
With a partner	14,113	44.36	9,979	43.49
Without a partner	17,704	55.64	12,967	56.51
Dual Coverage				
No	29,694	93.33	21,468	93.56
Yes	2,123	6.67	1,478	6.44
CMG				
701	3,174	9.98	1,656	7.22
702	6,523	20.50	3,736	16.28
703	11,300	35.52	7,856	34.24
704	10,820	34.01	9,698	42.26
Tier				
None	19,002	59.72	12,719	55.43
Major	782	2.46	588	2.56
Medium	2,004	6.30	1,669	7.27
Minor	10,029	31.52	7,970	34.73
Facility type				
Freestanding	17,045	53.57	12,413	54.10
Unit in hospital	14,772	46.43	10,533	45.90
Region				
P01	1,686	5.30	1,255	5.47
P02	1,551	4.87	977	4.26
P03	3,825	12.02	2,763	12.04
P04	8,248	25.92	5,980	26.06
P05	2,696	8.47	2,034	8.86
P06	7,689	24.17	5,542	24.15
P07	1,458	4.58	1,193	5.20
P08	915	2.88	699	3.05
P09	3,469	10.90	2,259	9.84
P10	280	0.88	244	1.06

Table 1-3: Descriptive statistics of cardiac patients among traditional Medicare beneficiaries

TM N=28,151	Pre-pandemic Mean	N=17,871 SD	During-pandemic Mean	N=10,280 SD
Age	78.25164	0.0537227	78.03842	0.0707294
Certified Beds	50.73398	0.2494935	49.71342	0.3304625
	N	**%**	**N**	**%**
Gender				
Male	9,684	54.19	5,529	53.78
Female	8,187	45.81	4,751	46.22
Race				
NH White	15,496	86.71	9,014	87.68
NH Black	1,475	8.25	783	7.62
Hispanic	571	3.2	301	2.93
Other	329	1.84	182	1.77
Marital Status				
With a partner	8,575	47.98	4,787	46.57
Without a partner	9,296	52.02	5,493	53.43
Dual Coverage				
No	16,437	91.98	9,457	91.99
Yes	1,434	8.02	823	8.01
CMG				
1401	2,493	13.95	1,141	11.1
1402	6,714	37.57	3,518	34.22
1403	4,878	27.3	2,843	27.66
1404	3,786	21.19	2,778	27.02
Tier				
None	6,104	34.16	3,114	30.29
Major	1,028	5.75	680	6.61
Medium	1,608	9	1,048	10.19
Minor	9,131	51.09	5,438	52.9
Facility type				
Freestanding	9,147	51.18	5,494	53.44
Unit in hospital	8,724	48.82	4,786	46.56
Region				
P01	867	4.85	500	4.86
P02	656	3.67	351	3.41
P03	2,044	11.44	1,248	12.14
P04	5,335	29.85	2,945	28.65
P05	2,535	14.18	1,511	14.7
P06	3,523	19.71	1,937	18.84
P07	898	5.02	621	6.04
P08	257	1.44	236	2.3
P09	1,574	8.81	828	8.05
P10	182	1.02	103	1

Table 1-4: Descriptive statistics of joint replacement patients among traditional Medicare beneficiaries

TM N=15,551	Pre-pandemic Mean	N=10,505 SD	During-pandemic Mean	N=5,046 SD
Age	75.86911	0.0672867	76.1843	0.0968734
Certified Beds	52.55954	0.3273665	50.46373	0.4701078
	N	**%**	**N**	**%**
Gender				
Male	3,640	34.65	1,814	35.95
Female	6,865	65.35	3,232	64.05
Race				
NH White	9,123	86.84	4,494	89.06
NH Black	733	6.98	306	6.06
Hispanic	340	3.24	146	2.89
Other	309	2.94	100	1.98
Marital Status				
With a partner	5,117	48.71	2,442	48.39
Without a partner	5,388	51.29	2,604	51.61
Dual Coverage				
No	9,805	93.34	4,736	93.86
Yes	700	6.66	310	6.14
CMG				
801	2,320	22.08	748	14.82
802	2,063	19.64	793	15.72
803	2,250	21.42	1,103	21.86
804	2,405	22.89	1,326	26.28
805	1,467	13.96	1,076	21.32
Tier				
None	6,153	58.57	2,817	55.83
Major	98	0.93	56	1.11
Medium	276	2.63	167	3.31
Minor	3,978	37.87	2,006	39.75
Facility type				
Freestanding	4,371	41.61	2,317	45.92
Unit in hospital	6,134	58.39	2,729	54.08
Region				
P01	398	3.79	224	4.44
P02	662	6.3	234	4.64
P03	1,537	14.63	760	15.06
P04	1,896	18.05	906	17.95
P05	858	8.17	382	7.57
P06	3,076	29.28	1,515	30.02
P07	494	4.7	282	5.59
P08	351	3.34	191	3.79
P09	1,081	10.29	455	9.02
P10	152	1.45	97	1.92

Table 2-1: IV regression results of mobility and cognitive score improvement of stroke patients among traditional Medicare beneficiaries

	Mobility Score Improvement	**Cognitive Score Improvement**
2nd Stage	Coefficient (SE)	Coefficient (SE)
LOS	0.440***	0.898***
	(0.018)	(0.039)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0564***	1.0581***
	(0.0002)	(0.0003)
Predicted Mean	9.756	24.268
Relative Change	4.51%	3.70%
Observation	85,737	85,737

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors

***p < 0.01; **p < 0.05; *p < 0.10.

Table 2-2: IV regression results of mobility and cognitive score improvement of hip fracture patients among traditional Medicare beneficiaries

	Mobility Score Improvement	**Cognitive Score Improvement**
2nd Stage	Coefficient (SE)	Coefficient (SE)
LOS	0.567***	0.943***
	(0.094)	(0.210)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0582***	1.0600***
	(0.0005)	(0.0005)
Predicted Mean	12.606	31.843
Relative Change	4.50%	2.96%
Observation	54,763	54,763

Models are controlled by necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 2-3: IV regression results of mobility and cognitive score improvement of cardiac patients among traditional Medicare beneficiaries

	Mobility Score Improvement	**Cognitive Score Improvement**
2nd Stage	Coefficient (SE)	Coefficient (SE)
LOS	0.475***	0.832***
	(0.149)	(0.309)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0669***	1.0692***
	(0.0008)	(0.0008)
Predicted Mean	10.800	28.518
Relative Change	4.39%	3.16%
Observation	28,151	28,151

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 2-4: IV regression results of mobility and cognitive score improvement of joint replacement patients among traditional Medicare beneficiaries

	Mobility Score Improvement	Cognitive Score Improvement
2nd Stage	Coefficient (SE)	Coefficient (SE)
LOS	0.089	0.493**
	(0.100)	(0.230)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0793***	1.0825***
	(0.0013)	(0.0014)
Predicted Mean	13.818	38.267
Relative Change	0.64%	3.16%
Observation	15,551	15,551

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 3-1: IV analysis results of discharge location of stroke patients among traditional Medicare beneficiaries

	Multinomial Logistic Regression	Multinomial Probit Regression
2nd Stage	RRR	Coefficient (SE)
Home	Reference	Reference
LOS		
Home Health	1.051***	0.037***
	(0.007)	(0.005)
SNF	1.069***	0.043***
	(0.009)	(0.006)
Others	0.809***	-0.127***
	(0.008)	(0.007)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0564***	1.0581***
	(0.0002)	(0.0003)
Observation	85,737	85,737

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors

***p < 0.01; **p < 0.05; *p < 0.10.

Table 3-2: IV analysis results of discharge location of hip fracture patients among traditional Medicare beneficiaries

	Multinomial Logistic Regression	Multinomial Probit Regression
2nd Stage	RRR	Coefficient
Home	Reference	Reference
LOS		
Home Health	1.018	0.006
	(0.037)	(0.027)
SNF	0.956	-0.012
	(0.045)	(0.032)
Others	0.661***	-0.240***
	(0.041)	(0.038)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0582***	1.0600***
	(0.0005)	(0.0005)
Observation	54,763	54,763

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 3-3: IV analysis results of discharge location of cardiac patients among traditional Medicare beneficiaries

2nd Stage	Multinomial Logistic Regression RRR	Multinomial Probit Regression Coefficient
Home	Reference	Reference
LOS		
Home Health	0.921*	-0.080**
	(0.040)	(0.033)
SNF	1.051	0.019
	(0.075)	(0.045)
Others	0.731***	-0.176***
	(0.046)	(0.041)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0669***	1.0692***
	(0.0008)	(0.0008)
Observation	28,151	28,151

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 3-4: IV analysis results of discharge location of joint replacement patients among traditional Medicare beneficiaries

2nd Stage	Multinomial Logistic Regression RRR	Multinomial Probit Regression Coefficient
Home	Reference	Reference
LOS		
Home Health	1.065*	0.044
	(0.036)	(0.027)
SNF	1.117*	0.071*
	(0.069)	(0.040)
Others	0.913	-0.016
	(0.070)	(0.045)
1st Stage	Coefficient (SE)	IRR (SE)
Expected LOS	0.0793***	1.0825***
	(0.0013)	(0.0014)
Observation	15,551	15,551

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 4-1: IV analysis results of successfully returning to community after discharge of stroke patients among traditional Medicare beneficiaries

	Logistic Regression	Linear Probability Regression	Probit Regression
2nd Stage	OR	Coefficient	Coefficient
Return to community (Yes=1)			
LOS	1.073***	0.016***	0.042***
	(0.006)	(0.001)	(0.003)
1st Stage	Coefficient (SE)	IRR (SE)	
Expected LOS	0.0564***	1.0581***	
	(0.0002)	(0.0003)	
Observation	85,737	85,737	85,737

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 4-2: IV analysis results of successfully returning to community after discharge of hip fracture patients among traditional Medicare beneficiaries

2nd Stage	Logistic Regression OR	Linear Probability Regression Coefficient	Probit Regression Coefficient
Return to community (Yes=1)			
LOS	1.199***	0.0005	0.082***
	(0.037)	(0.005)	(0.018)
1st Stage	Coefficient (SE)	IRR (SE)	
Expected LOS	0.0582***	1.0600***	
	(0.0005)	(0.0005)	
Observation	54,763	54,763	54,763

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 4-3: IV analysis results of successfully returning to community after discharge of cardiac patients among traditional Medicare beneficiaries

2nd Stage	Logistic Regression OR	Linear Probability Regression Coefficient	Probit Regression Coefficient
Return to community (Yes=1)			
LOS	1.095**	-0.0011	0.036
	(0.045)	(0.005)	(0.023)
1st Stage	Coefficient (SE)	IRR (SE)	
Expected LOS	0.0669***	1.0692***	
	(0.0008)	(0.0008)	
Observation	28,151	28,151	28,151

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.

Table 4-4: IV analysis results of successfully returning to community after discharge of joint replacement patients among traditional Medicare beneficiaries

2nd Stage	Logistic Regression OR	Linear Probability Regression Coefficient	Probit Regression Coefficient
Return to community (Yes=1)			
LOS	1.012	0.0016	0.003
	(0.046)	(0.0045)	(0.024)
1st Stage	Coefficient (SE)	IRR (SE)	
Expected LOS	0.0793	1.0825	
	(0.0013)	(0.0014)	
Observation	15,551	15,551	15,551

Models are controlled for necessary clinical factors, demographics, facility factors, and regional factors
***p < 0.01; **p < 0.05; *p < 0.10.