

# Post-stroke rehabilitation

## Factors predicting discharge to acute versus subacute rehabilitation facilities

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### Abstract

The aim of this study was to examine predictors of discharge of hospitalized stroke patients to either an acute inpatient rehabilitation facility (IRF) or subacute skilled nursing facility (SNF).

A retrospective cohort study was done in a large multicampus urban academic medical center of individuals hospitalized for stroke between January 1, 2015 and December 31, 2015 and who were discharged to either an IRF (n=84) or SNF (n=59). A set of characteristics and scales were collected on each patient and assessed using univariate and multivariate regression analyses.

Although univariate analyses revealed multiple measures were associated with discharge destination, the most predictive multivariate logistic regression model for discharge to SNF incorporated age (odds ratio [OR] = 1.09, 95% confidence interval [CI], 1.05–1.13), premorbid physical disability (OR 7.52, 95% CI 1.66–34.14), and inability to ambulate before discharge (OR 5.84, 95% CI 2.01–16.92) with an overall c-statistic of 0.85.

Increasing age, premorbid physical disability, and inability to ambulate increase the overall likelihood of discharge to a SNF. These findings need to be replicated in larger samples to determine whether they are generalizable.

**Abbreviations:** ADL = activities of daily living, AMPAC = activity measure for post acute care, AMPAC-BM = activity measure for post acute care-basic mobility, AMPAC-DA = activity measure for post acute care-daily activity, CI = confidence interval, FIM = functional independence measure, IADL = instrumental activities of daily living, IRF = acute inpatient rehabilitation facility, mCCI = Modified Charlson Comorbidity Index, NIHSS = National Institutes of Health Stroke Scale, OR = odds ratio, REDCap = Research Electronic Data Capture, SNF = skilled nursing facility.

**Keywords:** cerebrovascular accident, discharge, prediction, rehabilitation, stroke, stroke survivor

### 1. Introduction

Approximately 795,000 people sustain a new or recurrent stroke each year and stroke is the fifth leading cause of death in the United States.<sup>[1,2]</sup> Stroke is also one of the leading causes of long-term disability, leaving more than half of stroke survivors

aged  $\geq 65$  years with impaired mobility.<sup>[1,2]</sup> In 2014, the average hospital length of stay before discharge for a patient with a primary diagnosis of a stroke was 4.7 days,<sup>[1]</sup> reflecting a trend towards shorter hospital stays and earlier discharge to post-acute care. The average annual cost from 2013 to 2014 of direct healthcare for stroke patients was estimated to be \$23.6 billion, which included outpatient visits, inpatient stays, emergency department visits, medications, and home healthcare.<sup>[1]</sup> Informal caregivers such as family or friends provide much of the post-discharge care to stroke survivors.<sup>[3]</sup> This incurs not only a financial, but physical and psychological burden for these informal caregivers leading to risk of depression, cardiovascular diseases, increased mortality, and a decreased quality of life.<sup>[3–5]</sup>

Although independent mobility before discharge is a predictor of discharge home,<sup>[6–8]</sup> there are no detailed predictive models assessing multiple patient characteristics to determine post-acute stroke rehabilitation care. Rehabilitation facilities include inpatient rehabilitation facilities (IRFs) and skilled nursing facilities (SNFs). Based on Medicare regulations that govern the care of most post-stroke care, IRFs require patient to participate in at least 3 hours of rehabilitation therapy per day with frequent physician encounters and medical necessity for a hospital level of care.<sup>[9]</sup> SNFs are short-term facilities or units within nursing homes that provide variable amounts of rehabilitation therapy and typically include infrequent physician services.<sup>[9,10]</sup> Accurate prediction of post-acute discharge destination earlier in a patient's stay could assist with the determination of rehabilitation goals and facilitate the discharge planning process resulting in a more efficient and targeted manner.<sup>[11]</sup>

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Previous studies have assessed various factors that influence discharge location, focusing on home versus post-acute discharge destinations. These factors have included age, sex, race, type of stroke, stroke severity, length of stay, stroke interventions, medical comorbidities, National Institutes of Health Stroke Scale (NIHSS), Motor Assessment Scale, Functional Independence Measure (FIM), Activity Measure for Post Acute Care (AMPAC), neuro-cognitive dysfunction as well as environmental and socioeconomic factors.<sup>[8,11–19]</sup> Other studies have examined the factors that distinguish patients who receive post-acute care after stroke at IRF versus SNF and found that age, pre-morbid function, activity of daily living (ADL) impairments, sociodemographics and geographic location contribute.<sup>[9,20–23]</sup> Most of these studies have used administrative data and have lacked detailed clinical information that might influence discharge destination selection. We therefore undertook this study to examine the factors that influence selection of post-acute level of care for stroke survivors.

## 2. Methods

This was an institutional review board–approved retrospective analysis of patients at Columbia University Medical Center system. Data were retrospectively collected from patients with the primary diagnosis of a stroke. They were included if they were admitted to 1 of 2 campuses (community or academic) of a large multicampus urban medical center during 2015 and if they were 18 years or older. Of this cohort, patients were excluded based on several criteria: admission from a rehabilitation facility or group home, discharge to hospice or long-term care facilities, discharge after 2015, transfer from another hospital or index stroke (first stroke in the year of 2015) occurred at another hospital, not given the final diagnosis of a new stroke, developed a stroke during a hospital admission for another medical condition, active malignancy or life-threatening condition other than a stroke, transient ischemic accident or subdural hemorrhage, the clinical examination and radiology findings not consistent with one another, or expired during hospitalization.

Members of the study team reviewed the medical records of each patient admitted from January 1, 2015 to December 31, 2015 with a primary diagnosis of a stroke. A set of standardized data abstraction forms were created in Research Electronic Data Capture (REDCap) and used to collect information about age, sex, time between stroke onset and admission, length of hospital stay, discharge site, stroke type and location, thrombolytic therapy, modified Charlson Comorbidity Index (mCCI) scores, insurance type, rehabilitation service consultation, family support, inability to tolerate 3 hours of therapy, premorbid physical disability, premorbid dementia, inability to ambulate before hospital discharge, and barriers affecting discharge. Additionally, the last recorded values for NIHSS scores, AMPAC scores of basic mobility (BM) and daily activity (DA), and Modified Rankin Scale (mRS) scores were assessed. Of note, Charlson Comorbidity typically includes stroke as one point in the score, but was modified to not be included in our study given that every patient in the study carried this diagnosis. Also, physical medicine & rehabilitation service consultation was initially analyzed, but was eventually excluded because of a clear institutional bias to obtain these consultations mainly for patients being assessed for admission to the hospital's IRF.

Initial univariate analyses were performed to test for significance and association between individual patient characteristics and discharge level of care. Categorical variables were

tested using the  $\chi^2$  test or Fisher exact test, as appropriate. Continuous variables were analyzed using 2-tailed *t* tests. To assess for compliance of the *t* test assumptions, Levene test for equality of variances was used. Of note, NIHSS was converted from continuous to categorical variables. NIHSS was also analyzed as both a continuous and dichotomous variable based on scores of  $\geq 16$ , or  $\leq 15$ , representing the commonly used threshold between moderate and severe strokes. A *P* value  $< .05$  in the univariate analysis was used to identify significant variables for regression analysis. A binary logistic regression model was used to assess for variable association with discharge destination and relative significance in the overall model in comparison to covariables. The final model reveals associations that were only considered significant at *P* values  $< .05$ . All analyses were performed using SPSS Version 24 (IBM Corp. Released 2016, IBM SPSS Statistics for Mac, Version 24.0, Armonk, NY).

## 3. Results

### 3.1. Cohort description

The complete study included 2892 patients. After exclusion, a total of 143 patients were analyzed in the study based on data from the subjects' acute hospitalization course (Fig. 1). Of these subjects, 84 (58.7%) were discharge to IRF and 59 (41.3%) were discharged to SNF. Demographic characteristics are summarized in Table 1.

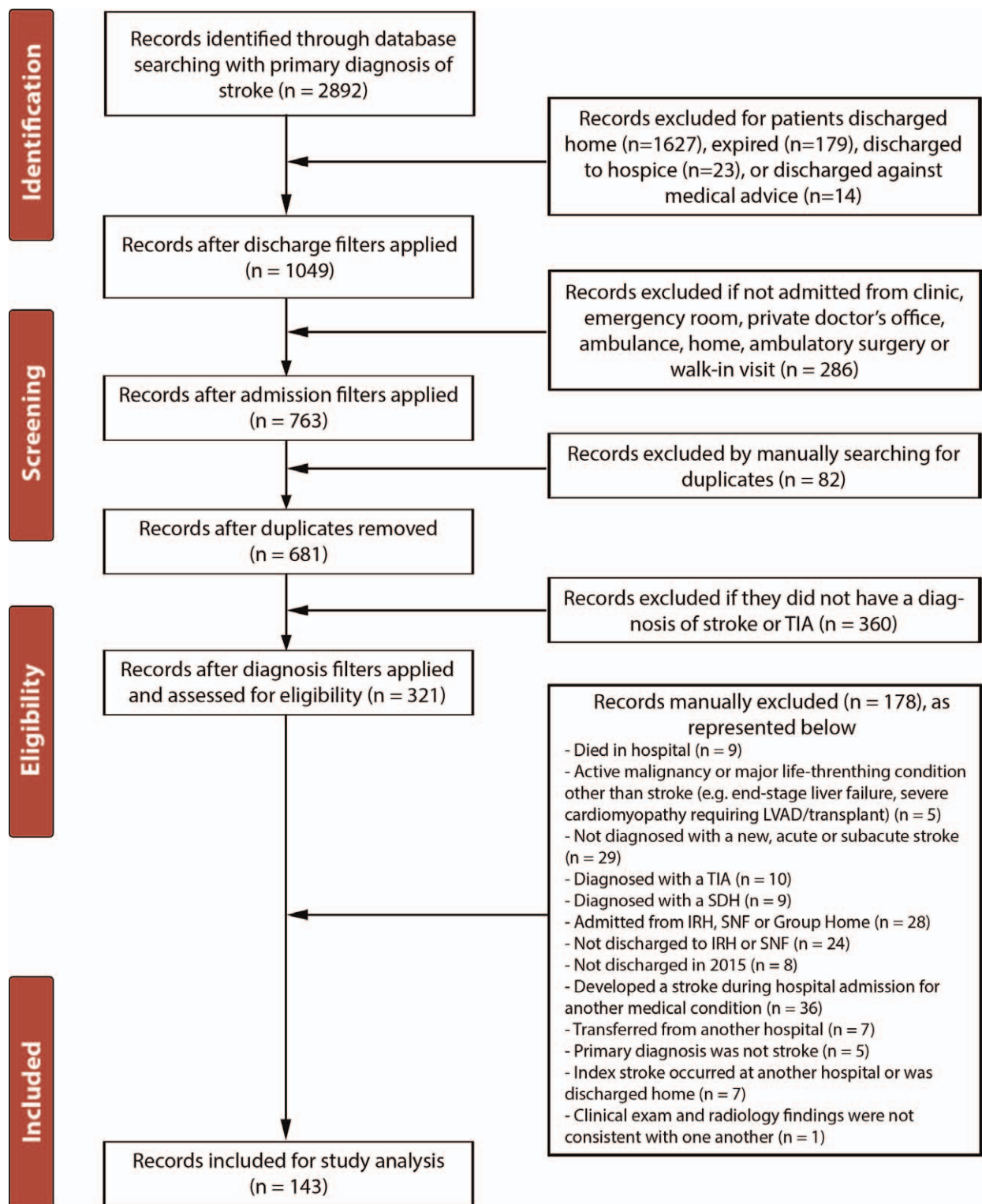
### 3.2. Univariate analysis

A univariate analysis was performed on all continuous and categorical variables. Significance was found for age, hospital length of stay, NIHSS, NIHSS score  $> 15$ , AMPAC-BM, AMPAC-DA, mRS, mCCI, inability to tolerate 3 hours of rehabilitation therapy per day, premorbid physical disability, inability to ambulate, and barriers affecting discharge, as shown in Table 2.

### 3.3. Multivariate analysis

Multiple binary regression models were performed on significant variables from the univariate analyses. Given the sample size limitation, a maximum of 5 variables were used per model. Each model included age, premorbid functional disability and inability to ambulate based on previous research determining that these are key factors as well as clinical experience demonstrating that these are foundational variables used in the clinical decision-making process. The last variable was analyzed with a variation of each of the functional scales (mRS, AM-PAC, NIHSS, mCCI). The most predictive model was selected based on all variables being statistically significant ( $P < .05$ ) and a high c-statistic. Additionally, collinearity of the variables was evaluated before the finalization of the model (Table 3). Table 4 illustrates the adjusted odds ratios (ORs) and 95% confidence interval (CI) results of the regression models.

The most predictive model demonstrated that for every-year increase in a subject's age they were 1.09 times more likely to be discharged to SNF (OR 1.09, 95% CI 1.05–1.13) and if the subject had a premorbid physical disability before their stroke, they were 7.52 times more likely to be discharged to SNF (OR 7.52, 95% CI 1.66–34.14). Finally, patients unable to ambulate before discharge were 5.84 times more likely to be discharged to SNF (OR 5.84, 95% CI 2.01–16.92). The model was found to have an overall c-statistic of 0.85 (Table 4 - Model 1).



**Figure 1.** Flow diagram for the selection of eligible patients for the study. IRH = inpatient rehabilitation facility, LVAD = left ventricular assist device, SDH = subdural hematoma, SNF = skilled nursing facility, TIA = transient ischemia accident.

#### 4. Discussion

Previous studies have examined factors such as NIHSS, pre-morbid disability, and age predicting discharge destination. However, most of these studies do not distinguish between IRF and SNF for discharge to a post-acute rehabilitation facility. The

results of this study reveal that age, pre-morbid physical disability, and inability to ambulate predict discharge to SNF with an overall c-statistic of 0.85. This model allows a simplified method of assessment that may help predict the ultimate post-acute rehabilitation discharge destination.

**Table 1**  
**Demographics.**

Characteristics	N	N (%)	Mean	STD
Age	143		74.87	14.04
Sex	143			
Male		64 (44.76)		
Female		79 (55.24)		
Days until admission after stroke	142		1.81*	3.84
Admission campus	143			
Academic center		115 (80.42)		
Community		28 (19.58)		
Stroke type	143			
Ischemic		111 (77.60)		
Hemorrhagic		19 (13.30)		
Both		13 (9.10)		
Previous stroke	142			
Yes		45 (31.69)		
No		97 (68.31)		
Length of stay, days	143		10.04	8.18
Insurance	143			
Medicaid		37 (25.87)		
Medicare		89 (62.23)		
Commercial		16 (11.19)		
Self-pay		1 (0.70)		
Discharge	143			
IRF		84 (58.74)		
SNF		59 (41.26)		

IRF = inpatient rehabilitation facility, SNF = skilled nursing facility, STD = standard deviation.

\* Median value was equal to 1.00.

**Table 2**  
**Univariate analysis.**

Characteristics	Total	IRH			SNF			OR	95% CI for OR		P
		N (%)	Mean	STD	N (%)	Mean	STD		Lower	Upper	
Age	143	84	68.95	12.62	59	83.31	11.46				<.001
Gender (female)	143	41 (48.80)			38 (64.40)			1.90	0.96	3.76	.07
Days after stroke until admission	142	83	2.01	4.39	59	1.53	2.90				.46
Admission campus (community)*	143	13 (15.50)			15 (25.40)			1.86	0.81	4.28	.14
Length of hospital stay, days	143	84	8.96	8.28	59	11.58	7.85				.06
Stroke type—ischemic	143	64 (76.20)			47 (79.70)						.63
Stroke type—hemorrhagic		13 (15.50)			6 (10.20)						
Stroke type—both		7 (8.30)			6 (10.20)						
tPA given, yes	143	12 (14.30)			10 (16.90)			1.22	0.49	3.06	.66
History of stroke, yes	142	24 (28.90)			21 (35.50)			1.36	0.67	2.77	.40
NIHSS	134	80	4.90	4.27	54	7.69	7.92				.02
NIHSS $\geq 15^{\dagger}$	142	1 (1.19)			8 (13.79)			13.28	1.61	109.35	<.001
AMPAC-BM	125	71	13.42	3.79	54	10.98	4.25				<.001
AMPAC-DA	125	76	15.28	3.42	49	12.65	4.98				<.001
mRS	135	80	2.84	1.23	55	3.45	1.15				<.001
mCCI	143	84	1.32	0.60	59	1.59	0.77				.03
Insurance (commercial and self-pay) <sup>‡</sup>	143	14 (16.70)			3 (13.79)			0.27	0.07	0.98	.04
Insufficient family support, yes	141	0 (0)			4 (5.10)			—	—	—	.05
Inability to tolerate 3 hours of therapy, yes	97	1 (1.28)			6 (6.90)			35.54	3.95	319.80	<.001
Pre-morbid physical disability, yes	141	3 (3.61)			13 (22.41)			7.70	2.08	28.48	<.001
Pre-morbid dementia, yes	141	6 (7.23)			11 (18.97)			3.00	1.04	8.66	.04
Cognitive-communication disability, yes	141	8 (9.60)			12 (20.70)			2.45	0.93	6.43	.06
Inability to ambulate, yes	141	8 (9.64)			24 (41.38)			6.62	2.70	16.23	<.001
Barriers to discharge, yes	142	4 (4.76)			15 (25.86)			6.98	2.18	22.33	<.001

AMPAC-BM = Activity Measure for Post Acute Care-Basic Mobility Short Form Score, AMPAC-DA = Activity Measure for Post Acute Care-Daily Activity Short Form Score, CI = confidence interval, IRF = inpatient rehabilitation facility, mCCI = modified Charlson Comorbidity Index, mRS = Modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, OR = odds ratio, SNF = skilled nursing facility, STD = standard deviation, tPA = tissue plasminogen activator.

\* Referent is academic hospital.

<sup>†</sup> Referent is NIHSS <15.<sup>‡</sup> Referent is Medicare and Medicaid.



**Table 3**  
Colinearity analysis of predictive model (model 1).

	Age	Premorbid physical disability*	Inability to ambulate*
Age	1.00	0.09	0.07
Premorbid physical disability*	0.09	1.00	0.09
Inability to ambulate*	0.07	0.09	1.00

\* Referent is No.

We found that age is a predictor of discharge to SNF. Our predictive model reveals that the odds of patients within this older group being discharged to SNF is 1.09 times more likely for every year increase in the patient's age. The elderly often require a higher level of care for longer periods of time and may be less able to care for themselves upon discharge. The Northern Manhattan Stroke Study found that the probability of discharge to a nursing facility for patients older than 65 years of age was 2.4-fold.<sup>[24]</sup> Other studies have similarly found that there is an association between increased age and reduced likelihood of discharge to IRF compared with SNF.<sup>[7,20]</sup>

Patients with a premorbid physical disability and inability to ambulate before discharge were found to be 7.52 and 5.84 times, respectively, more likely to be discharged to SNF. These findings are unsurprising because of the bias for IRFs in accepting patients who are likely to return to the community. Premorbid physical disability included patients that had alterations in their ADLs and

instrumental ADLs (iADLs) requiring some level of assistance ranging from assistive devices to family members and home health aids directly providing care. Of note, AMPAC-BM is also a measure of a patient's mobility given various tasks such as walking 1 mile, making sharp turns and running short distances.<sup>[25]</sup> However, inability to ambulate is easier to measure and more ubiquitously available. The results reveal that these patients likely require a longer rehabilitation course to achieve a level of functioning necessary to be safely discharged home and are at a higher risk of requiring long-term care owing to the cumulative effects of previous disability compounded by the index stroke.

Finally, the mCCI is a compilation of serious medical conditions that not only predict 1-year mortality, but also serve as a surrogate for medical complexity of a patient.<sup>[26,27]</sup> Other studies have used various scales such as mRS, AM-PAC, FIM, and NIHSS to identify characteristics of patients discharged to post-acute rehabilitation facilities.<sup>[13–15,28–30]</sup> Multiple multivariate regression models were run utilizing mCCI, mRS, AM-PAC, and NIHSS, which revealed no statistically significant contribution to discharge prediction. This is likely a result of increasing age being correlated with a patient's likelihood of having increasing medical complexity.

## 5. Limitations

Our study has several potential limitations. First, our study included subjects within a single institution representing a

**Table 4**  
Predictors of discharge to subacute rehabilitation (multivariate analysis).

Model	Characteristics	P	OR	95% CI for OR		c-Statistic
				Lower	Upper	
1	Age	<.001	1.09	1.05	1.13	0.85
	Premorbid physical disability*	.01	7.52	1.66	34.14	
	Inability to ambulate*	<.001	5.84	2.01	16.92	
2	Age	<.001	1.09	1.05	1.13	0.86
	mCCI	.08	1.73	0.94	3.20	
	Premorbid physical disability*	.02	6.35	1.39	28.96	
3	Inability to ambulate*	<.001	6.27	2.09	18.86	0.86
	Age	<.001	1.10	1.06	1.14	
	NIHSS	.67	0.98	0.90	1.07	
4	Premorbid physical disability*	.01	8.60	1.85	40.09	0.86
	Inability to ambulate*	<.001	7.70	1.97	30.07	
	Age	<.001	1.09	1.05	1.13	
5	NIHSS $\geq 15$ †	.46	2.41	0.24	24.62	0.86
	Premorbid physical disability*	.01	7.97	1.78	35.77	
	Inability to ambulate*	.01	5.07	1.60	16.02	
6	Age	<.001	1.10	1.06	1.14	0.86
	AMPAC-BM	.95	1.00	0.87	1.14	
	Premorbid physical disability*	.01	10.08	1.67	60.98	
7	Inability to ambulate*	.01	5.08	1.43	18.03	0.87
	Age	<.001	1.10	1.06	1.15	
	AMPAC-DA	.59	1.04	0.90	1.19	
8	Premorbid physical disability*	.01	10.21	1.66	62.89	0.86
	Inability to ambulate*	<.001	7.04	1.92	25.80	
	Age	<.001	1.10	1.06	1.15	
9	mRS	.50	1.15	0.77	1.71	0.87
	Premorbid physical disability*	.01	8.52	1.78	40.90	
	Inability to ambulate*	.01	5.31	1.58	17.85	

AMPAC-BM = Activity Measure for Post Acute Care-Basic Mobility Short Form Score, AMPAC-DA = Activity Measure for Post Acute Care-Daily Activity Short Form Score, CI = confidence interval, IRF = inpatient rehabilitation facility, mCCI = modified Charlson Comorbidity Index, mRS = modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, OR = odds ratio, SNF = skilled nursing facility.

\* Referent is No.

† Referent is NIHSS <15.

particular geographic region, which would limit our study's generalizability to all stroke survivors discharged to post-acute rehabilitation facilities. Additionally, given the retrospective nature of the study, it is limited by data contained within the electronic medical records, which could not be corroborated by assessing the actual patients.

Finally, an important limitation is that there is no generally accepted "criterion standard" to determine which patients should receive IRF versus SNF care. Our study assessed existing patterns of care, but we cannot determine whether these patterns represent the optimal level of care selection for these patients. Some guidance is provided by the American Heart Association Stroke Rehabilitation Guidelines,<sup>[20]</sup> but our sample predated those guidelines. Thus, there are no published studies examining how consistently these stroke guidelines are being followed for this purpose.

## 6. Conclusion

This research study demonstrates that increasing age, premorbid physical disability, and inability to ambulate increase the overall likelihood of discharge to a SNF. Of all the scales compared, NIHSS, AMPAC-BM and DA, mRS, and mCCI were found to be significant in the univariate analyses. However, these scales were found to be not statistically significant when it came to prediction of discharge destination.

Our analyses reflect current practice at one institution, rather than optimal practice. Our observations reflect actual practice rather than optimal care, and should not be used as a guide to determine which level of post-acute care stroke survivors should receive. Our findings can nonetheless inform future research on developing optimal care paths for stroke survivors by highlighting existing practice patterns and subjecting these to scrutiny and possible modification. Ultimately, outcome studies that incorporate the patient outcomes of post-acute care, both medically (eg, hospital readmission and recurrent stroke) and functionally (return to community, activities of daily living, and mobility status), are needed to determine the "right" level of rehabilitation for various subpopulations of stroke survivors.

## Author contributions

**Conceptualization:** Neal Rakesh, Daniel Boiarsky, Shaliesha Hinds, Joel Stein.

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**Visualization:** Neal Rakesh, Daniel Boiarsky, Ammar Athar, Shaliesha Hinds, Joel Stein.

**Writing – original draft:** Neal Rakesh, Joel Stein.

**Writing – review & editing:** Neal Rakesh, Joel Stein.

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