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Predicting length of stay in patients admitted to stroke rehabilitation with severe and moderate levels of functional impairments

Alejandro García-Rudolph, PhD[a,b,c,*], Blanca Cegarra, MSc[a,b,c,d], Eloy Opisso, PhD[a,b,c], Josep María Tormos, PhD[a,b,c], Montserrat Bernabeu, MD[a,b,c], Joan Saurí, PhD[a,b,c]

Abstract

Severe stroke patients are known to be associated with larger rehabilitation length of stay (LOS) but other factors besides severity may be contributing. We aim to identify LOS predictors within a population of mostly severe patients and analyze the impact of socioeconomic situation in functionality at admission.

A retrospective observational cohort study was conducted including 172 inpatients admitted to a rehabilitation center between 2007 and 2019. Associations with LOS were examined among 30 potential predictor variables using bivariate correlations. Significantly correlated ($P < .002$, Bonferroni adjustment) variables were entered into 9 different multiple linear regression models.

No mild participants were included, 63.37% severe and 36.63% moderate. Most significant LOS determinants were: 1) total functional independence measure (FIM) ($P < .001$) and hemiparesis ($P = .0108$) (adjusted $R^2 = 0.24$), 2) cognitive FIM ($P = .002$) and severity ($P = .001$) (adjusted $R^2 = 0.22$), and 3) home accessibility ($P = .043$) and hemiparesis ($P = 0.032$) (adjusted $R^2 = 0.19$).

Known LOS predictors (e.g., depression, ataxia) within the full stroke severities were not found significant in our dataset.

Socioeconomic situation was found moderately correlated with total FIM ($r = -0.32$, $P < .0001$).

When stratifying the patients' socioeconomic situation into mild, important, and severe social risk, their respective median total FIM at admission were 61.5, 50, and 41, with significant differences between the mild and important group ($P < .001$); also significant differences were found between mild and severe groups ($P < .001$).

A few of the variables identified in the literature as significant predictors of LOS within the full stroke population were also significant for our dataset (National Institutes of Health Stroke Scale, FIM, home accessibility) explaining less than 25% of the LOS variance. Most of the 30 analyzed known predictors were not significant (e.g., depression, age, recurrent stroke, ataxia, orientation, verbal communication, etc) suggesting that factors outside functional, socioeconomic, medical, and demographics not included in this study (e.g., rehabilitation sessions intensity) have important influences on LOS for severe patients.

Patients at mild social risk obtained significantly higher total FIM at admission than patients at important and severe social risk. The importance of socioeconomic situation has been scarcely studied in the literature in relation to functionality at admission; our results suggest that it requires to be considered.

Abbreviations: C-FIM = cognitive FIM, ECO = economic, ENV = environmental, FAM = family, FIM = functional independence measure, LOS = length of stay, M-FIM = motor FIM, NIHSS = National Institutes of Health Stroke Scale, PACI = partial anterior circulation infarcts, POCI = posterior circulation infarcts, SEQ = socioeconomic questionnaire, SOC = social, SUP = support, T-FIM = total FIM.

Keywords: inpatients, length of stay, regression analysis, rehabilitation, socioeconomic status, stroke

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

[a] Department of Research and Innovation, Institut Guttmann, Institut Universitari de Neurorehabilitació adscrit a la UAB, Badalona, [b] Universitat Autònoma de Barcelona, Bellaterra (Cerdanyola del Vallès), [c] Fundació Institut d'Investigació en Ciències de la Salut Germans Trias i Pujol, Badalona, [d] Universitat de Barcelona, Barcelona, Spain.

[*] Correspondence: Alejandro García-Rudolph, Department of Research and Innovation, Institut Guttmann—Hospital de Neurorehabilitació, Cami Can Ruti s/n 08916—Badalona, Barcelona, Spain (e-mail: alejandropablogarcia@gmail.com).

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1. Introduction

Stroke rehabilitation length of stay (LOS) is one of the most relevant quantitative indexes that measure health service utilization within a hospital. LOS is the principal predictive factor of medical expenses among variables that affect the total costs during hospitalization.[1] The ability to accurately predict which stroke patients are likely to require longer inpatient care is desirable for both budgetary planning and healthcare providers' considerations as well as to manage emotional expectations when communicating with patients and families.[2]

Many factors have been shown to influence subacute rehabilitation LOS, including stroke severity measured with the National institute of Health Stroke Scale (NIHSS),[3] ability to perform activities of daily living,[4] or admission Functional Independence Measure (FIM) score.[5] The presence of ataxia may increase LOS,[6] dysphagia,[7] as well as aphasia,[8] diabetes,[9] obesity,[10] and hypertension.[11] Besides, recurrent stroke patients have been previously reported requiring longer LOS.[12]

Furthermore, there is evidence that motor[13] and cognitive[14] rehabilitation after stroke should be started as early as possible. Nevertheless, time since stroke onset to rehabilitation admission has been scarcely included as covariate in LOS predictive models.

Falls are common post-stroke (12%–47%) and may extend inpatient stroke rehabilitation LOS[15] as well as depression.[16] In terms of social factors, there are conflicting reports about whether living alone predicts LOS, for example, Tan et al (longer LOS),[17] Saxena et al (shorter LOS).[18] Besides, inadequate family support[19] and environmental factors (e.g., home modifications) may delay LOS.[20]

A 2015 Lancet review[21] reports that socioeconomic status (SES) is reflected in short-term and long-term outcomes after stroke. Studies have demonstrated an association between lower SES and having more severe deficits after stroke assessed by NIHSS at admission.[22] To our best knowledge there is a lack of similar studies addressing associations between functional independence, for example, total FIM(T-FIM), motor FIM (M-FIM), and cognitive FIM (C-FIM) at admission and SES.

Although several researchers have previously examined the prediction of LOS within the full spectrum of stroke rehabilitation patients (mild, moderate, and severe), different variables may have different impact in LOS when excluding the population with mild functional impairments. For example, while age has previously been identified as a significant contributor of LOS, this variable may not have the same impact for severe and milder patients as the latter group tends to be younger.[5] To classify stroke severity at admission as mild, moderate, or severe, in this work, we apply the RPG benchmark (Rehabilitation Patient Groups), as in similar previous research.[23]

The objectives of the present study are to analyze the associations between functional independence (T-FIM, M-FIM, and C-FIM) at admission and SES within a population of ischemic and hemorrhagic (moderate-RPG and severe-RPG) stroke patients admitted to an inpatient rehabilitation hospital and predict their LOS from a wide range of potential predictors, including the aforementioned demographics, clinical, and social state-of-the-art variables.

It is hypothesized that M-FIM, C-FIM, and T-FIM at admission will have a stronger association (negative correlation) with SES than NIHSS.

It is also hypothesized that, while some of the same variables that have been identified as significant predictors of LOS within the full stroke population will also emerge for this sample, a different composite of predictors will best account for the variance associated with LOS for patients admitted to stroke rehabilitation with severe and moderate functional impairments.

2. Materials and methods

2.1. Study design

A quantitative, longitudinal, retrospective review of health records was conducted for patients who completed the inpatient stroke rehabilitation program at an urban rehabilitation hospital, between September 2007 and November 2019.

This study conforms to the STROBE guidelines.[24]

2.2. Participants

The inclusion criteria for the study were adult patients with the diagnosis of stroke, both ischemic or hemorrhagic, who were admitted within 3 weeks of the onset of symptoms, without any previous comorbidities leading to disability. Exclusion criteria were diagnosis of stroke in the context of another concomitant comorbidity (e.g., traumatic brain injury) and a previous history of another disabling condition. Cases of transient ischemic attack or subarachnoid hemorrhage were not included. Persons were only included in the current study if they were 18 to 85 years of age at the time of stroke, and the database included complete data within a week of admission and discharge.

2.3. Measurements

Patients were classified into RPGs as described in the related research.[23] RPG severity is based on age and functional ability (evaluated using the FIM at admission).

Medical complications and comorbidities (reported using ICD9 codes) were collected from the participants' electronical health records (EHRs). After a frequency analysis, less frequent were discarded (presented in SupMaterial) and the following were included as predictor variables: diabetes, ataxia, aphasia, dysphagia, depression, hypertension, dyslipidemia, and atrial fibrillation (all of them recorded as yes/no). Missing values were completed by means of the specific internal or external reports.

Demographics (age, sex, education, marital status), stroke characteristics (type and location), functionality (T-FIM, M-FIM, and C-FIM) scores at admission and discharge, time since stroke onset to rehabilitation admission after discharge from an acute stroke care facility (in days), were also obtained from EHRs.

The socioeconomic situation is assessed since 2007 in Institut Guttmann hospital by means of the Socioeconomic Questionnaire (SEQ).[25] It involves 5 items described in Table 1: home family (SEQ-FAM), economy (SEQ-ECO), home physical (SEQ-ENV), family support (SEQ-SUP), and need of social support (SEQ-SOC).

A fall is defined according to the Falls Management protocol following the Joint Commission International standards and managed according to the hospital protocols.

FIM gain was computed by calculating the difference between FIM scores at admission and at discharge. The FIM efficiency is FIM gain divided by LOS in days.

The LOS for each patient was determined by calculating the number of days between the date of admission and discharge.

Table 1

Description of items of the Socioeconomic Questionnaire (SEQ).

Item	Description	Score
HOME FAMILY (LIVING WITH, CORE OF COEXISTENCE) (FAM-SEQ)	Ranges from: Lives with family/core of coexistence or stable partner (1 point) to lives alone, no relatives close (5 points)	Range 1–5
ECONOMY (ECO-SEQ)	Ranges from: Own and/or family/core of coexistence with sufficient and stable incomes (1 point) to own and/or family/core of coexistence with no fix incomes received	Range 1–5
HOME PHYSICAL (ENV-SEQ)	Ranges from: Appropriate to your needs (1 point) to cannot return home (4 points) and no home (5 points)	Range 1–5
FAMILY SUPPORT (SUP-SEQ)	Ranges from: Autonomous or no support needed from family/core of coexistence (1 point) to Rejected or abandoned by family or by core of coexistence (4 points) and no family/no core of coexistence (5 points)	Range 1–5
NEED SOCIAL SUPPORT (INFORMAL/FORMAL) (SOC-SEQ)	Ranges from autonomous or with enough informal support (1 point) to Needs public institutional alternative (e.g., long-term sociosanitary center or assisted (4 points) and cannot access to public support (e.g., foreigner without residence card) (5 points)	Range 1–5
TOTAL (TOT-SEQ)	The overall score, determines 4 categories: no social risks (5 points), mild social risks (6–9 points), important social risks (10–14), and severe social risks (≥15 points)	Range 5–25

2.4. Statistical analyses

All statistical analyses were performed in R-v3.5.1 (64 bits), level of significance was set at $P=.05$. Patients were stratified into 2 RPG groups (moderate-RPG and severe-RPG). Descriptive statistics were used for demographic characteristics of participants as well as functional and socioeconomic assessments. The 2 RPG groups were compared using the χ^2 test for categorical variables and the Kruskal–Wallis test for continuous and ordered variables.

Associations with LOS were examined among 30 potential predictor variables using bivariate (Pearson or Spearman as appropriate) correlations. Using Cohen criteria, associations were considered weak below 0.10, moderate between 0.10 and 0.49, and strong between 0.50 and 1.00.[26] To maintain the experiment-wise error rate at $P<.05$, a Bonferroni adjustment was used (0.05/30 = 0.0017). Significantly correlated variables were included in a multiple regression analysis using the enter method to predict LOS.

Multicollinearity of independent variables is tested by the variance inflation factor (VIF) and the tolerance (1/VIF). Tolerance is associated with each independent variable and ranges from 0 to 1. A tolerance below 0.40 and/or a VIF of 5 or 10 and above indicates a multicollinearity problem.[27]

The assumption of independent errors is evaluated using the Durbin–Watson. The closer to 2 that the value is, the better. As a conservative rule it is suggested that for values less than 1 or greater than 3 the assumption of independence is not met.[27]

2.5. Ethical considerations

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The study was approved by the hospital's Ethics Committee of Clinical Research. The participants were anonymized and nonidentifiable. Participants did not provide written informed consent to be included specifically in this study, they provide informed consent to be included in research studies addressed by the hospital.

3. Results

A total of 2135 ischemic and hemorrhagic stroke patients were admitted to the hospital's rehabilitation unit during the period under study (September, 2007 to November, 2019). After excluding 243 patients with more than 3 weeks since stroke onset to admission, 247 with more than 1 week since admission to FIM assessment and 244 with more than 1 week since admission to SEQ assessment a total of 1421 were assessed for discharge conditions. After excluding 326 with more than 1 week since FIM assessment to discharge, 1095 patients were assessed for data quality constraints. After removing incomplete records (289 missing M-FIM at admission, 258 C-FIM at admission, 91 T-FIM at discharge, 209 SEQ at admission, 42 with missing demographic data) and 4 outliers with LOS ≥ to the 98th percentile, of the 202 remaining records, 29 with no NIHSS in acute phase were removed, leaving the final 172 records (details in Fig. 1).

Table 2 presents the characteristics of the study sample. Of the total 172 included patients, 63.37% are severe-RPG and 36.63% are moderate-RPG.

The percentage of male patients was 66.7%. The mean (standard deviation) age was 51.72 (11.1) years, no significant differences were found between both groups in relation to age.

The mean (standard deviation) time since stroke onset to admission across severities was 17.89 (4.36) days (no significant differences between groups), similar to related research (e.g., McClure et al[5] with 16.04 (15.21)). The percentage of ischemic patients is 70.3%.

3.1. FIM and SES assessments at admission

In relation to functionality, at admission severe-RPG patients had significantly lower C-FIM ($P=.007$), M-FIM ($P<.001$), and T-FIM ($P<.001$) than moderate-RPG patients; similarly, at discharge significantly lower M-FIM ($P<.001$) and T-FIM ($P<.001$).

But severe-RPG patients had significantly higher scores than moderate-RPG when considering FIM Gain ($P<.001$), ENV-SEQ ($P<.001$), and TOT-SEQ ($P=.007$), as shown in Table 3.

When stratifying the TOT-SEQ score into *mild* social risk, *important* social risk, and *severe* social risk using the criteria for stratification presented in Table 1, the median TOT-SEQ value of the moderate RPG group is 9.00 (7.00, 10.00) therefore the moderate-RPG group belongs to the *mild* social risk level. Meanwhile, the median TOT-SEQ value of the severe-RPG group is 10.00 (8.00, 12.00), therefore the severe-RPG group belongs to the *important* social risk level ($P=.007$).

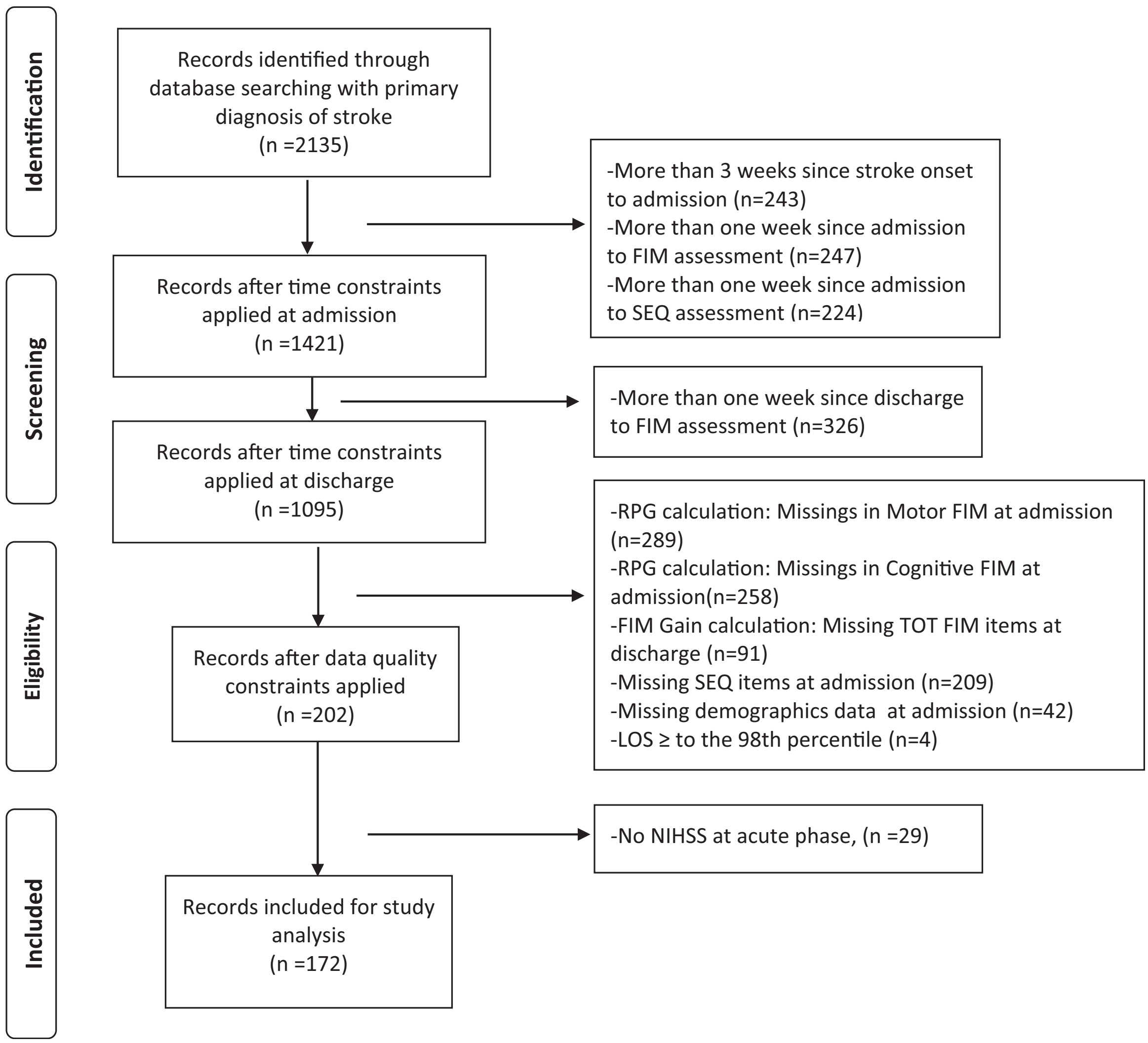

Figure 1. Patient selection flowchart.

3.2. Bivariate correlation analysis: NIHSS, SES, and FIM at admission and discharge

Several strong correlations were found between stroke severity and functionality: NIHSS and T-FIM-Adm are strongly correlated ($r=-0.51$, $P<.0001$) as well as T-FIM-Adm and T-FIM-Dis ($r=0.51$, $P<.0001$).

In relation to socioeconomic situation, TOT-SEQ correlated moderately with C-FIM-Adm ($r=-0.22$, $P=.01$), with M-FIM-Adm ($r=-0.27$, $P<.001$) and slightly stronger with T-FIM-Adm ($r=-0.32$, $P<.0001$), being weaker the correlation with NIHSS ($r=0.19$, $P<.05$) (Table 4).

Other moderate associations involving socioeconomic items are presented in sup material, the most relevant are: ENV-SEQ correlated positively with FIM gain ($r=0.24$, $P=.01$) and negatively with T-FIM-Adm ($r=-0.33$, $P<.001$); meanwhile, SOC-SEQ also correlated negatively with T-FIM-Adm ($r=-0.25$, $P<.001$).

Age is associated with worse FIM gain ($r=-0.23$, $P=.01$) and with worse T-FIM-Dis ($r=-0.30$, $P<.001$).

3.3. The impact of socioeconomic situation in FIM at admission and NIHSS

In this section we take as a starting point the stratification of the TOT-SEQ score into *mild* social risk, *important* social risk, and *severe* social risk using the criteria for stratification presented in Table 1.

T-FIM and NIHSS scores at admission are presented in Figure 2 and Table 5. The median T-FIM at admission for the mild, important, and severe groups were 61.5, 50, and 41, with significant differences between the *mild* and *important* group ($P<.001$); also significant differences were found between *mild* and s*evere* group ($P<.001$).

The median NIHSS for the mild, important, and severe groups were 13, 14, and 16. significant differences were found between mild and severe groups ($P<.05$).

Notes: Box plot (minimum-minimum-lower quartile-median-upper quartile-maximum); the numbers in the box indicate the median; $^{**}P<.01$.

Table 2

Characteristics at admission for the total patients included in the study.

	Moderate-RPG (N=63)	Severe-RPG (N=109)	Total (N=172)	*P*
Male	42 (66.7%)	71 (65.1%)	113 (65.7%)	.839
Age in years, mean (SD)	49.58 (10.8)	52.95 (11.1)	51.72 (11.1)	.065
Ischemic stroke	47 (74.6%)	74 (67.9%)	121 (70.3%)	.353
TACI	37 (58.7%)	66 (60.6%)	103 (59.9%)	.111
PACI	8 (12.7%)	3 (2.8%)	11 (6.4%)	
POCI	2 (3.2%)	4 (3.7%)	6 (3.5%)	
Hemorrhagic primary	9 (14.3%)	26 (23.9%)	35 (20.3%)	
Hemorrhagic secondary	7 (11.1%)	9 (8.3%)	16 (9.3%)	
Hemiparesis LEFT	23 (36.5%)	55 (50.5%)	78 (45.3%)	.077
TSO mean (SD)	17.52 (4.57)	18.10 (4.24)	17.89 (4.36)	.461
NIHSS acute phase	**11.68 (5.20)**	**14.68 (4.7)**	**13.58 (5.1)**	**<.001**
Hypertension	41 (65.1%)	83 (76.1%)	124 (72.1%)	.119
Dislipidemia	23 (36.5%)	38 (34.9%)	61 (35.5%)	.828
Dysphagia	**13 (20.6%)**	**46 (42.2%)**	**59 (34.3%)**	**.004**
Diabetes	14 (22.2%)	26 (23.9%)	40 (23.3%)	.807
Atrial fibrillation	4 (6.3%)	15 (13.8%)	19 (11.0%)	.135
Ataxia	2 (3.2%)	5 (4.6%)	7 (4.1%)	.651
Aphasia	26 (41.3%)	50 (45.9%)	76 (44.2%)	.558
Depression	**30 (47.6%)**	**75 (68.8%)**	**105 (61.0%)**	**.006**
Recurrent stroke	9 (14.3%)	7 (6.4%)	16 (9.3%)	.087
BMI mean (SD)	26.05 (5.33)	26.89 (5.26)	26.58 (5.29)	.24
Primary level of education	28 (44.4%)	53 (48.6%)	81 (47.1%)	.865
Secondary level of educ	21 (33.3%)	33 (30.3%)	54 (31.4%)	
Higher education	14 (22.2%)	23 (21.1%)	37 (21.5%)	
Marital status				
Married	40 (63.5%)	69 (63.3%)	109 (63.4%)	.299
Single	16 (25.4%)	27 (24.8%)	43 (25.0%)	
Divorced	4 (6.3%)	5 (4.6%)	9 (5.2%)	
Widow	0 (0.0%)	6 (5.5%)	6 (3.5%)	
Separated	3 (4.8%)	2 (1.8%)	5 (2.9%)	
Smoking habits				
Current	15 (23.8%)	19 (17.4%)	34 (19.8%)	.599
Former	6 (9.5%)	11 (10.1%)	17 (9.9%)	
Non	42 (66.7%)	79 (72.5%)	121 (70.3%)	
Inpatient falls	15 (23.8%)	40 (36.7%)	55 (32.0%)	.081
LOS mean (SD)	**49.82 (19.12)**	**72.39 (27.86)**	**64.12 (27.23)**	**<.001**
OPTIMAL LOS	5 (7.9%)	19 (17.4%)	24 (14.0%)	.083

BMI=body mass index, LOS=length of stay, NIHSS=National Institutes of Health Stroke Scale, PACI=partial anterior circulation infarcts, POCI=posterior circulation infarcts, SD=standard deviation, TACI=total anterior circulation infarcts, TSO=time since stroke onset to admission.
Significant *P* values ($P<.05$) should be in bold.

Table 3

Functional independence measures (at admission and discharge) and Socioeconomic Questionnaire at admission.

	Moderate-RPG (N=63)	Severe-RPG (N=109)	Total (N=172)	*P*
C-FIM Adm	**23.36 (7.44)**	**19.05 (9.74)**	**20.63 (9.18)**	**.007**
M-FIM Adm	**50.57 (10.87)**	**23.57 (8.25)**	**33.46 (16.00)**	**<.001**
T-FIM Adm	**73.93 (10.76)**	**42.63 (15.73)**	**54.09 (20.66)**	**<.001**
C-FIM Dis	27.41 (6.84)	24.94 (8.34)	25.84 (7.89)	.086
M-FIM Dis	**73.03 (9.44)**	**57.79 (19.08)**	**63.37 (17.79)**	**<.001**
T-FIM Dis	**100.44 (11.40)**	**82.74 (23.80)**	**89.22 (21.86)**	**<.001**
FIM Gain	**26.50 (12.39)**	**40.11 (22.34)**	**35.12 (20.34)**	**<.001**
FIM efficiency mean (SD)	0.60 (0.41)	0.62 (0.39)	0.62 (0.40)	.358
FIM efficiency Med (P1 P3)	0.53 (0.34, 0.64)	0.63 (0.34, 0.87)	0.56 (0.34, 0.84)	
FAM-SEQ	1.31 (0.94)	1.45 (1.00)	1.40 (0.98)	.249
ECO-SEQ	1.49 (0.84)	1.68 (1.05)	1.61 (0.98)	.231
ENV-SEQ	**1.66 (0.80)**	**2.23 (0.92)**	**2.02 (0.91)**	**<.001**
SUP-SEQ	2.46 (0.61)	2.58 (0.62)	2.54 (0.62)	.167
SOC-SEQ	2.36 (0.97)	2.57 (0.98)	2.49 (0.98)	.182
TOT-SEQ mean (SD)	**9.30 (2.98)**	**10.52 (3.26)**	**10.07 (3.20)**	**.007**
TOT-SEQ Med (P1 P3)	**9.00 (7.00, 10.00)**	**10.00 (8.00, 12.00)**	**9.50 (8.00, 11.00)**	

C-FIM=cognitive FIM, ECO=economic, ENV=environmental, FAM=family, FIM=functional independence measure, Med=median, M-FIM=motor FIM, SD=standard deviation, SEQ=socioeconomic questionnaire, SOC=social, SUP=support, TOT=total, T-FIM=M-FIM+C-FIM, T-FIM=total FIM.
Significant *P* values ($P<.05$) should be in bold.

Table 4

Correlations of FIM at admission and discharge with SEQ and NIHSS.

	NIHSS	M-FIM Adm	C-FIM Adm	T-FIM Adm	TOT-SEQ	LOS	T-FIM Dis	FIM Gain
NIHSS	1							
M-FIM Adm	−0.43***	1						
C-FIM Adm	−0.47***	0.39***	1					
T-FIM Adm	−0.51***	0.93***	0.64***	1				
TOT-SEQ	0.19*	−0.27***	−0.22**	−0.32***	1			
LOS	0.25**	−0.50***	−0.25**	−0.51***	0.26***	1		
T-FIM Dis	−0.42***	0.44***	0.17*	0.51***	−0.20**	−0.25**	1	
FIM Gain	ns	−0.42***	−0.14+	−0.42***	0.13+	0.20**	0.49***	1

FIM gain = total FIM at discharge—total FIM at admission, C-FIM Adm = cognitive FIM at admission, LOS = length of stay, M-FIM Adm = motor FIM at admission, NIHSS = National Institutes of Health Stroke Scale, ns = non-significant, SEQ = socio economic questionnaire, T-FIM Adm = total FIM at admission, T-FIM Dis = total FIM at discharge.
* $P \leq 0.05$.
** $P \leq 0.01$.
*** $P \leq 0.001$.

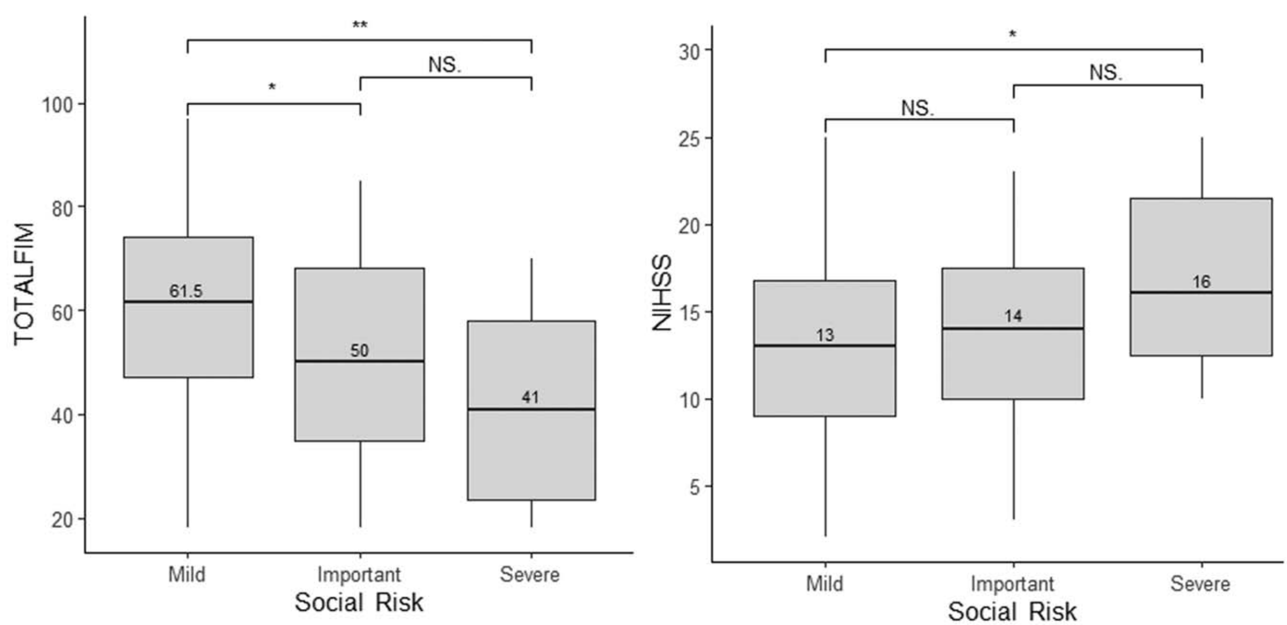

Figure 2. Comparison of functional independence measure at admission and NIHSS among the 3 social risk groups. NIHSS = National Institutes of Health Stroke Scale.

Table 5

SEQ, NIHSS, and FIM for each social risk level.

	Mild (N = 86)	Important (N = 71)	Severe (N = 15)	Total (N = 172)	*P*
TOT-SEQ					**<.001**
Mean (SD)	7.73 (1.06)	11.31 (1.29)	17.67 (2.69)	10.08 (3.20)	
Median	8.00 (7.00, 9.00)	11.00 (10.00, 12.00)	17.00 (16.00, 18.00)	9.50 (8.00, 11.00)	
Range	6.000–9.000	10.00–14.00	15.00–24.00	6.00–24.00	
T-FIM Adm					**.002**
Mean (SD)	59.06 (20.29)	50.87 (19.90)	40.93 (18.63)	54.09 (20.67)	
Median	61.50 (47.00, 74.00)	50.00 (35.00, 68.00)	41.00 (23.50, 58.00)	56.00 (36.00, 71.00)	
Range	18.000–97.000	18.000–85.000	18.00–70.00	18.00–97.00	
NIHSS					**.049**
Mean (SD)	12.94 (5.09)	13.69 (4.93)	16.800 (5.240)	13.587 (5.124)	
Median	13.00 (9.00, 16.75)	14.00 (10.00, 17.50)	16.00 (12.50, 21.50)	13.00 (9.75, 17.00)	
Range	2.000–25.000	3.000–23.000	10.000–25.000	2.000–25.000	

FIM = functional independence measure, NIHSS = National Institutes of Health Stroke Scale, SEQ = socio economic questionnaire, T-FIM Adm = total FIM at admission.
Significant *P* values ($P < .05$) should be in bold.

Table 6

Correlations with LOS.

	r	P	R^2
Severity (moderate/severe)	**0.4003865**	**<.000001**	**0.1602**
Gender male	0.0484579	.5279	
Age	0.0662903	.3876	
Marital status (married/not)	0.037076	.6292	
Type ischemic/hemorr	−0.01053576	.8909	
Side of paresis (left/right)	−0.1855227	.01483	
Time since onset to Adm	0.0221928	.7726	
NIHSS	**0.2471814**	**.001079**	**0.0576**
M-FIM Adm	**−0.5006698**	**<.000001**	**0.2506**
C-FIM Adm	**−0.2472141**	**.001078**	**0.0611**
T-FIM Adm	**−0.5063567**	**<.000001**	**0.2563**
Depression	**0.221513**	**.003497**	
Current smoker	−0.04964352	.5178	
BMI	0.08178256	.2862	
Hypertension	0.09270506	.2264	
Dysphagia	0.1333635	.08114	
Dyslipidemia	0.07571433	.3236	
Ataxia	0.0649127	.3975	
Diabetes	−0.007660164	.9206	
Atrial fibrillation	0.08089877	.2914	
Aphasia	0.01757197	.819	
Recurrent stroke	**−0.1761855**	**.02078**	
FAM-SEQ	0.1443192	.05892	
ECO-SEQ	0.1791327	.01871	
ENV-SEQ	**0.2449986**	**.001199**	**0.0599**
SUP-SEQ	0.174516	.02204	
SEC-SEQ	0.1443091	.05893	
TOT-SEQ	**0.2649201**	**.0004447**	**0.07017**
Education low/med-high	0.007391863	.9233	
Fallers	0.1078687	.159	

BMI = body mass index, C-FIM Adm = cognitive FIM at admission, ECO = economic, ENV = environmental, FAM = family, FIM = functional independence, LOS, length of stay, M-FIM Adm = motor FIM at admission, NIHSS = National Institutes of Health Stroke Scale, SEQ = socio economic questionnaire, SOC = social, SUP = support, TOT = total, T-FIM Adm = total FIM at admission. Variables with $P < .002$ should be in bold.

3.4. Bivariate correlation analysis: demographics, clinical, and social variables with LOS

Potential associations with LOS were examined among 30 variables using bivariate correlations. The following variables (Table 6) were significantly correlated with LOS:

severity (moderate-RPG and severe-RPG), NIHSS, M-FIM-Adm, C-FIM-Adm, T-FIM-Adm, ENV-SEQ, and TOT-SEQ.

No other variables were found to be significant at our conservative α level (0.05/30 = 0.0017); however, it should be noted that side of paresis, depression, recurrent stroke, and 2 socioeconomic items (ECO-SEQ and SUP-SEQ) were all significantly correlated with LOS at $P < .05$.

3.5. Multivariate regression analysis

As shown in sup material M-FIM-Adm, C-FIM-Adm, T-FIM-Adm are strongly correlated, as well as ENV-SEQ and TOT-SEQ; therefore, we included the following variables in model #1: severity, NIHSS, T-FIM-Adm, and TOT-SEQ (presented in Table 7). A significant model emerged ($P < .00001$) with an adjusted $R^2 = 0.1982$ ($R^2 = 0.2176$), T-FIM-Adm contributed significantly to the model; nevertheless, it presents a multicollinearity problem (tolerance = 0.35).

Multiple lineal 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 (as in similar previous research[28]). Nine significant models emerged as presented in Table 7, highest R^2 values were obtained in model #2 adjusted $R^2 = 0.2442$ ($R^2 = 26.19$) with side of paresis and T-FIM-Adm contributing significantly.

FIM scores significantly contributed to model #3, #4, and #5; meanwhile, depression did not contribute to any of them.

Model #6 is composed by 3 variables, the 3 of them contribute significantly: NIHSS, severity, and hemiparesis, adj $R^2 = 0.1885$ and $R^2 = 0.2027$.

Models #7, #8, and #9 show significant contributions of the socioeconomic variables, highest R^2 values are obtained in model #8 which includes ENV-SEQ instead of TOT-SEQ, adj $R^2 = 0.1952$, $R^2 = 0.2141$.

3.6. Bivariate correlation analysis in a subsample: cognition variables with LOS

The initial n = 172 patients were analyzed in relation to cognition assessments at admission. Therefore, we identified a subset of almost 70% of the initial sample (n = 118 with 44 moderate-RPG and 74 severe-RPG) who were assessed in cognition items according to the inclusion criteria.

In the initial sample 63.37% were severe-RPG and 36.63% were moderate-RPG, similarly, in this subset 62.71% were severe-RPG and 37.29% were moderate-RPG.

Measurements of cognition included: temporal orientation, spatial orientation, personal orientation, verbal comprehension, verbal denomination, and verbal repetition, as well as 5 C-FIM items (auditory comprehension, verbal expression, social interaction, memory, and problem solving).

As shown in supplementary material (http://links.lww.com/MD/E966), neither orientation nor verbal fluency items correlated with LOS. Two of the 5 C-FIM items were significantly correlated with LOS (social interaction and problem resolution) but C-FIM was already included in 1 of the models presented in the previous section (model #4) and in this work we did not further analyze the specific contribution of C-FIM items.

4. Discussion

Previous studies have mostly focused on investigating the prediction of LOS within the full severity spectrum of stroke rehabilitation patients. Such studies involved a wide range of number of participants, e.g., n = 586,[29] n = 11,983,[2] n = 117,[19] n = 3839,[30] n = 151,[31] n = 165,[23] n = 353.[32]

To our best knowledge, very few previous studies targeted a specific severity group, for example McClure et al[5] analyzed predictors of LOS in patients (n = 134) admitted to stroke rehabilitation with high levels of functional independence (T-FIM > 100). According to their findings, the 2 most predictive variables were M-FIM score at admission and orientation to person, place, and time, although verbal communication ability also contributed significantly to the model, collectively accounting for 60% of the variance associated with LOS.[5] Our results, similar to McClure in number of participants and in the set of considered variables, also identified FIM score (motor, cognitive, and total) as the most predictive variables, but neither orientation to person, place, and time, nor verbal communication ability were found significant.

Table 7

Multivariate lineal regressions, nonstandard beta with CIs, standard beta, Durbin test, VIF, R^2, and adjusted R^2.

Model	Variables	b (95% CI)	*t* test	Std β	VIF	Tol	*P*	R^2	Adj R^2
1	Severity	9.33 (−1.97, 20.65)	1.63	0.16	2.20	0.45	.105	0.2176	0.1989
	NIHSS	0.028 (−0.81, 0.87)	0.067	0.005	1.37	0.72	.946		
	T-FIM-Adm	−0.39 (−0.69, −0.09)	−2.57	−0.29	2.83	**0.35**	.0108		
	TOT-SEQ	0.73 (−0.46, 1.93)	1.20	0.086	1.09	0.91	.229		
	Durbin test	D-W=1.81, *P*=.216							
2	Hemiparesis	−9.48 (−16.75, −2.22)	−2.579	−0.17	1.02	0.97	.0108	0.2619	0.2442
	Recurrent	−9.26 (−21.74, 3.20)	−1.467	−0.09	1.03	0.96	.1443		
	T-FIM-Adm	−0.54 (−0.71, −0.36)	−6.019	−0.41	1.05	0.94	<.0001		
	Depression	6.67 (−0.82, 14.17)	1.758	0.11	1.05	0.95	.0806		
	Durbin test	D-W=1.87, *P*=.386							
3	Hemiparesis	−9.54 (−16.91, −2.17)	−2.55	−0.17	1.05	0.95	.011	0.256	0.2382
	Severity	5.11 (−6.04, 16.28)	0.90	0.09	2.25	0.44	.366		
	T-FIM-Adm	−0.47 (−0.73, −0.21)	−3.60	−0.35	2.21	0.45	<.0001		
	Depression	6.36 (−1.18, 13.91)	1.66	0.11	1.05	0.94	.098		
	Durbin test	D-W=1.90 *P*=.59							
4	Hemiparesis	−12.55 (−20.60, −4.50)	−3.07	−0.23	1.22	0.81	.0024	0.241	0.2232
	Severity	16.26 (8.19, 24.34)	3.97	0.28	1.15	0.86	.00010		
	C-FIM-Adm	−0.69 (−1.13, −0.24)	−3.08	−0.23	1.26	0.78	.002384		
	Depression	7.36 (−0.23, −4.96)	1.91	0.13	1.05	0.95	.057		
	Durbin test	D-W=1.86, *P*=.35							
5	Hemiparesis	−5.85 (−13.34, 1.63)	−1.54	−0.10	1.05	0.95	.122	0.2308	0.2124
	Severity	5.81 (−7.24, 18.88)	0.88	0.10	2.99	**0.33**	.380		
	M-FIM-Adm	−0.54 (−0.94, −0.13)	−2.66	−0.31	3.10	**0.32**	.0085		
	Depression	6.24 (−1.45, 13.95)	1.60	0.11	1-06	0.93	.111		
	Durbin test	D-W=1.957, *P*=.78							
6	Hemiparesis	−9.86 (−17.55, −2.17)	−2.53	−0.18	1.074	0.93	.0122	0.2027	0.1885
	Severity	18.69 (10.53, 26.84)	4.52	0.331	1.13	0.88	<.000001		
	NIHSS	0.83 (0.05, 1.60)	2.12	0.156	1.14	0.87	.0352		
	Durbin test	D-W=1.87, *P*=.394							
7	Hemiparesis	−8.35 (−15.86, −0.85)	−2.19	−0.15	1.02	0.97	.0293	0.201	0.1867
	Severity	19.92 (12.03, 27.80)	4.98	0.353	1.05	0.94	<.000001		
	TOT-SEQ	1.21 (0.034, 2.39)	2.03	0.12	1.03	0.96	.0437		
	Durbin test	D-W=1.83, *P*=.266							
8	Hemiparesis	−8.25 (−15.81, −0.69)	−2.15	−0.15	1.04	0.95	.0326	0.2141	0.1952
	Severity	17.88 (9.68, 26.09)	4.30	0.31	1.15	0.86	<.000001		
	Recurrent	−12.20 (−25.18, 0.76)	−1.85	−0.13	1.04	0.95	.065		
	ENV-SEQ	4.56 (0.28, 8.85)	2.10	0.15	1.13	0.87	.0369		
	Durbin test	D-W=1.79, *P*=.188							
9	Hemiparesis	−7.64 (−15.16, −0.13)	−2.00	−0.14	1.03	0.96	.0462	0.2135	0.1946
	Severity	19.16 (11.26, 27.06)	4.78	0.34	1.07	0.93	<.000001		
	Recurrent	−10.59 (−23.45, 2.27)	−1.62	−0.11	1.03	0.96	.1059		
	TOT-SEQ	1.23 (0.05, 2.40)	2.07	0.14	1.03	0.96	.0399		
	Durbin test	D-W=1.81, *P*=.188							

C-FIM=cognitive FIM, ECO=economic, ENV=environmental, FAM=family, FIM=functional independence measure, M-FIM=motor FIM, NIHSS=National Institutes of Health Stroke Scale, SEQ=socioeconomic questionnaire, SUP=support, SOC=social, TOT=total, T-FIM=total FIM, T-FIM=M-FIM+C-FIM.

Our main contributing factor is T-FIM. As presented in Table 7, for model #2, T-FIM-Adm standardized Beta is −0.41, therefore, as T-FIM-Adm increases by 1 standard deviation (20.67 points) the LOS decreases by 0.41 standard deviations, the standard deviation of LOS is 27.23, so this constitutes a change of 11.16 days ($0.41\times27.23=11.16$); therefore, each 1 point improvement in T-FIM-Adm score predicted a reduction in LOS by 0.54 days. In Yang et al[19] T-FIM-Adm standardized Beta is −0.375, therefore, as T-FIM-Adm increases by 1 standard deviation (21.84 points) the LOS decreases by 0.375 standard deviations, the standard deviation of LOS is 22.11, so this constitutes a change of 8.29 days ($0.375\times22.11=8.29$); therefore, each 1 point improvement in T-FIM-Adm score predicted a reduction in LOS by 0.38 days according to Yang et al.[19]

M-FIM is our second main contributing factor, found as main factor in Grant et al[2] according to their results, each 1-point improvement in the M-FIM score predicted a reduction in LOS by 0.6 days. In our case, for model #5 M-FIM-Adm standardized Beta is −0.31; therefore, each 1 point improvement in M-FIM Adm score predicted a reduction in LOS by 0.52 days. In McClure et al[5] regression model M-FIM Adm standardized Beta is −0.29, each 1 point improvement in M-FIM-Adm score predicted a reduction in LOS by 0.51 days.

Each 1 point improvement in M-FIM score predicted a reduction in LOS of half a day in both McClure model (mild patients)[5] and in our model (mostly severe patients); meanwhile, Grant model (mild, moderate, and severe patients) predicted a slightly larger reduction in LOS (0.6 days).[2] As shown in Table 7 our model #5 may present some multicollinearity problem, tolerance is slightly below 0.40, but VIF is quite below 5; therefore, our values are acceptable.[27]

In McClure study,[5] social factors, such as informal support or family living arrangement, were not found significant contributors to LOS. Lai et al[23] identified some of them (e.g., living alone) as predictors of exceeding target LOS. Their study included all 3 severity levels (12.3% mild-RPG, 21% severe-RPG, and 55% moderate-RPG). Of the n = 165 included patients, 34% exceeded the optimal LOS; meanwhile in our case, applying the same criteria for optimal LOS, 86% of our patients exceeded it, as shown in Table 2. In Lai's sample, median LOS for moderate-RPG and severe-RPG patients were 29 and 48 days.[23] The median LOS reported in our study are 47 days for moderate-RPG and 67 days for severe-RPG. Lai's mean FIM gain were 23.1 (14.6) and 27.4(14.2),[23] in our case mean FIM gain were 26.50 (12.39) and 40.11 (22.4) respectively. This may indicate that larger LOS in severe-RPG in our sample may lead to larger FIM gain. But when considering FIM efficiency (defined as FIM gain divided by LOS) as presented in Table 3, we reported an FIM efficiency median of 0.53 for moderate-RPG and 0.63 for severe-RPG; meanwhile, Lai's are 0.8 and 0.6 respectively.[23] Therefore Lai's shows remarkable higher efficiency in moderate-RPG and we in severe-RPG.

In relation to specific socioeconomic variables, models #7, #8, and #9 in Table 7 include significant SEQ items. Our best adj r2 is obtained in model #8 which includes ENV-SEQ, as described in Table 1, ENV-SEQ refers to environmental, a.k.a. physical conditions at home, it ranges from *Appropriate to your needs* (1 point), *Architectural barriers with possibilities for adaptation* (2 points), or *Architectural barriers without possibility of adaptation* (3 points). As shown in Table 7 ENV-SEQ standardized Beta is 0.15, therefore each 1 point increase in ENV-SEQ score predicted an increase in LOS by 457 days.

Regarding recurrent stroke, Lai et al[23] conclude that patients with recurrent stroke require a longer LOS during inpatient rehabilitation than patients without recurrent stroke, independent of stroke severity. In our case recurrent stroke was included in 3 models in Table 7, but did not contribute significantly in any of them.

In relation to the explained variance, our best is model #2 (adj $R^2 = 24.42\%$), remarkably lower than McClure's. Our results in that sense are similar to Grant et al[2] their study includes all stroke severity levels and their multivariable regression model explains 20% of the variation of LOSs. Grant et al[2] considered a similar set of variables but a notably larger dataset (n = 11,983). Therefore, our results suggest that factors outside functional, socioeconomic, medical, and demographic patient characteristics have important influences on LOSs, being such factors more relevant in our dataset (which includes 63.37% severe-RPG) than in similar studies including mild patients or the full severity spectrum.

The second main aspect addressed in our study is the association between socioeconomic variables with stroke severity (NIHSS) and functionality at admission (T-FIM, M-FIM, and C-FIM).

The association between stroke severity and socioeconomic situation has been scarcely reported in previous research, for example, lower SES and having more severe deficits after stroke assessed by NIHSS at admission.[22]

According to our results, TOT-SEQ correlated moderately with C-FIM-Adm ($r = -0.22$, $P = .01$), with M-FIM-Adm ($r = -0.27$, $P < .001$) and slightly stronger with T-FIM-Adm ($r = -0.32$, $P < .0001$).

As presented in Table 1, higher values of TOT-SEQ indicate higher social risks, the negative correlations remark that higher social risks are moderately associated with lower cognitive, motor and total functionality at admission.

We also identified correlations between TOT-SEQ and NIHSS, in this case, the higher the social risk the higher the NIHSS ($r = 0.19$, $P < .05$); therefore, higher severity levels are also associated with higher social risks (though in this case the correlation is weaker than with FIM).

When stratifying TOT-SEQ score into mild social risk, important social risk, and severe social risk using the criteria for stratification presented in Table 1, we identified significant between-groups differences in functionality.

The median T-FIM at admission for the mild, important, and severe groups were 61.5, 50, and 41, with significant differences between the mild and important groups ($P < .001$); also significant differences were found between mild and severe groups ($P < .001$).

The median NIHSS for the mild, important, and severe groups were 13, 14, and 16. Significant differences were found between mild and severe groups ($P < .05$).

4.1. Study limitations

One of the main limitations of this study is a consequence of the data being collected in 1 single urban center that covered rehabilitation care, suggesting that the generalization of these results should be considered carefully. These findings need to be replicated in larger samples to determine whether they are generalizable.

Another limitation is that our models explained 24.42% of the total variance in LOS, which means that approximately 75% of the variation in LOS was influenced by other factors.

The median LOS reported in our study, 47 days for moderate-RPG patients and 67 days for severe-RPG patients, are quite long, especially when compared with LOS in the United States or Canada, for example, Grant et al[2] reported a median stroke rehabilitation LOSs of 35 days. Thus, our findings may not be generalizable to rehabilitation facilities in countries where LOS is significantly shorter. Nevertheless, a recent study in southern Ontario, Canada, involving n = 117 patients reported a median LOS of 45 days[19] quite similar to our moderate–RPG patients.

Previous studies have shown that higher severity as measured, for example, by NIHSS increases LOS, providing a possible explanation for our larger LOS. For example Appelros' multiple regression analysis showed that each point on the NIHSS increased the total LOS by 3.4 days.[3] Similarly, in our case, as presented in Table 7, for model #6, NIHSS standardized Beta is 0.156; therefore, each 1 point increase in NIHSS score predicted an increase in LOS by 0.83 days.

During the past few years, progress has been made toward identifying the roles of important inflammatory signaling molecules, cells, and proteins in the process of initiation and development of poststroke inflammation. Clinically, the susceptibility of the patients to stroke and the subsequent prognosis are influenced by such inflammatory processes.[33] As stroke patients with systemic inflammation have been reported to exhibit clinically poorer outcomes,[34] it is an important element to consider in future work. Specifically, increasing evidence shows that inflammation plays an important role in the progression of intracerebral hemorrhage inflammation.[35] Therapeutic targeting of inflammation in acute stroke has gained interest as a potential neuroprotective strategy. For example, matrix metalloproteinases are part of the neuro-inflammatory process that occurs during intracerebral hemorrhage and are, thus, also ideal as biomarkers and therapeutic targets in intracerebral hemorrhage treatment.[35] Notably, over recent decades C-reactive protein has been the focus of an intense investigation to explore its role in the setting of intracerebral hemorrhage and currently is proposed as a risk assessment tool and prognostic marker[36] and can also be considered in future research as an LOS potential predictor. Furthermore, the neutrophil-to-lymphocyte ratio[37] integrates information on both the innate and adaptive compartments of the immunity and represents a reliable measure of the inflammatory burden that could contribute to increasing knowledge about some of the mechanisms involved in the spontaneous intracerebral hemorrhage-induced injury and yield information on the disease course[37,38] and therefore can also be considered LOS predictor in future work.

5. Conclusions

In this study, we analyzed the associations between FIM at admission and SES within a population of ischemic and hemorrhagic stroke rehabilitation patients (nonmild according to RPG benchmark). We found that Motor FIM, Cognitive FIM, and TOTAL FIM at admission are moderately correlated with SES. Besides, we found that NIHSS is moderately correlated with SES, being this association weaker than with functional independence.

When stratifying the patients' socioeconomic situation into mild social risk, important social risk, and severe social, we identified significant between-groups differences in functionality between the mild social risk and important social risk group and between the mild social risk and severe social risk group.

Our results indicate an association between stroke functionality at admission and socioeconomic situation, confirming our first hypothesis.

We analyzed 30 state-of-the art predictors of LOS and found that a few of the same variables that have been identified as significant predictors of LOS within the full stroke population, were also significant predictors in our sample (FIM, home accessibility, NIHSS).

Nevertheless, most of LOS predictors found significant in the literature, were not for our sample, for example, depression, falls, recurrent stroke, ataxia, orientation, verbal communication.

In relation to the explained variance (24%), our results suggest that factors outside functional, socioeconomic, medical, and demographic patient characteristics have important influences on LOSs, being such factors more relevant in our dataset (which includes 63.37% severe-RPG) than in similar studies including mild patients or the full severity spectrum. Administrative and therapy-specific variables (intensity, therapy type, inpatient services, etc) may be important factors that influence LOS. These factors were neither measured nor evaluated in this study offering opportunities for future work.

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Author contributions

AGR, BC and JMT conceived the study, AGR and BC collected, selected, and cleaned the data. AGR, EO and JS performed the statistical analysis of the data. AGR and BC drafted the initial manuscript. EO, JMT, MB and JS revised the manuscript critically for important intellectual content and approved the final manuscript.

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