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Predictors of Functional Recovery After Stroke in 2014 and 2024: A Retrospective Study From a Portuguese Reference Rehabilitation Center

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Abstract

Background

Stroke is the leading cause of mortality and disability in Portugal. With population aging and increasing stroke incidence, identifying predictors of functional recovery is essential to guide rehabilitation referral and therapeutic decisions. Age, time to rehabilitation admission, admission functional status, aphasia, neglect, and National Institutes of Health Stroke Scale score have been proposed as predictors of recovery. This study aimed to identify clinical and demographic predictors of Functional Independence Measure (FIM) gain in patients undergoing inpatient post-stroke rehabilitation a decade apart, assess their influence on functional gain, and determine whether these associations changed over time.

Methodology

This retrospective, single-center study included 226 patients admitted to the Centro de Medicina de Reabilitação de Alcoitão in 2014 (138, 61%) and 2024 (88, 39%). Demographic and clinical variables included sex, age, premorbid autonomy, education, previous stroke, stroke subtype, acute hospital complications, referral source, time to rehabilitation admission, length of stay, aphasia, neglect, admission Functional Ambulation Categories (FAC), and admission and discharge FIM scores. Generalized linear models assessed associations between selected variables and FIM gain. The prespecified analysis included 217 complete cases (2014, n = 132; 2024, n = 85). FIM gain was subsequently modelled using significant predictors from each year to assess changes in their associations over the decade.

Results

The cohorts were comparable regarding demographic characteristics, premorbid functional status, stroke type, length of stay, and functional status at admission and discharge. Compared with 2014, patients admitted in 2024 were more frequently referred from hospitals, had a longer time from stroke to rehabilitation admission, and had a higher prevalence of neglect. In multivariable analyses, female sex, longer time to admission, and higher admission FAC were independently associated with lower FIM gain in 2014, whereas aphasia was associated with greater gain. In 2024, hospital referral was associated with greater FIM gain, while acute hospital complications and higher admission FAC were associated with lower gain. FIM gain was 16.95 in 2014 and 14.10 in 2024.

Conclusions

Factors associated with FIM gain differed over the decade. Female sex and delayed rehabilitation admission predicted lower gain in 2014, whereas aphasia predicted greater gain. In 2024, hospital referral predicted greater gain and acute hospital complications predicted lower gain. Higher admission FAC was consistently associated with lower FIM gain, although this finding warrants cautious interpretation. Limitations include the retrospective single-center design, selection of patients eligible for intensive rehabilitation, and the absence of stroke severity and other relevant clinical variables. Prospective studies incorporating these factors, rehabilitation intensity, and long-term outcomes are needed.

Categories: Neurology, Physical Medicine & Rehabilitation
Keywords: functional independence measure, functional outcomes, inpatient rehabilitation, prognostic factors, stroke

Introduction

Cerebrovascular diseases are among the leading causes of mortality and disability in Portugal and

worldwide, with approximately 80% of cases considered preventable [1-4]. Several prognostic factors associated with functional outcomes after stroke have been reported in the literature among patients undergoing structured multidisciplinary rehabilitation programs.

Considering the expected short-term increase in stroke incidence due to population aging, along with limited capacity for admissions to rehabilitation centers in Portugal, prognostic factors are of particular relevance for guiding decision-making regarding prioritization of access to healthcare resources, informing and managing patient and family expectations, and supporting the planning of post-discharge care [5].

With respect to functional prognostic factors, those most consistently highlighted in the literature include time interval between stroke onset and admission to a rehabilitation center, presence or absence of neglect and aphasia, age, functional status at admission, and National Institutes of Health Stroke Scale (NIHSS) score [5-12].

The primary aim of this retrospective study was to identify predictors of Functional Independence Measure (FIM) gain, as assessed by the Functional Independence Measure instrument (FIM is a trademark of Netsmart Technologies, Inc.) [13], in patients admitted to a rehabilitation center a decade apart. The secondary objectives were to assess their influence on functional gain during inpatient rehabilitation and to determine whether these associations changed over a decade-long period. The choice of a decade-long interval was prompted by the perception among the center's physicians that patients admitted for rehabilitation were becoming progressively older.

Materials And Methods

Study population

The Centro de Medicina de Reabilitação de Alcoitão (CMRA) is one of the four specialised rehabilitation centers in Portugal, primarily admitting patients from the Lisbon metropolitan area and Portuguese islands. A retrospective, single-center study was conducted at the CMRA, for which medical records of 226 patients admitted for post-stroke sequelae rehabilitation during 2014 (138, 61%) and 2024 (88, 39%) were accessed.

Patients whose admission represented a readmission, those who had previously been admitted to another rehabilitation center, and those who were discharged prematurely, either due to medical complications requiring transfer to an acute care hospital or due to the absence of meaningful benefit from the rehabilitation program as the patient's clinical condition precluded active participation, were excluded from the study.

At CMRA, each patient is admitted under the care of a team comprising a physiatrist, rehabilitation nurse, physiotherapist, speech and language therapist, occupational therapist, neuropsychologist, and social worker. Following admission, a meeting is held with the entire rehabilitation team to define therapeutic goals, considering the results of previous functional assessments in each domain. Weekly medical rounds are conducted in the ward and across the various departments to manage intercurrent events and monitor patient progress. Approximately halfway through the planned rehabilitation period, a reassessment meeting is held during which, in the presence of all team members, patient progress is reviewed, and therapeutic goals are adjusted as necessary. Each patient carries out an average of four hours of therapy daily. The rehabilitation dose was comparable in 2014 and 2024.

Demographic and clinic variables

Demographic characteristics and clinical data were retrieved from medical records. Accessed demographic data were sex, age, prior autonomy level, level of education, and history of presence of acute care previous stroke. Clinical data included type of stroke, hospital complications, referral source, time to admission in the rehabilitation center, length of stay, presence of neglect and aphasia, admission Functional Ambulation Category (FAC) [14] scale score, and total FIM score on admission and on discharge.

Predictors included in the analysis were selected based on the available scientific literature and were entered simultaneously: sex, age, type of stroke, acute care hospital complications, referral source, time to admission, FAC at admission, total FIM at admission, neglect, and aphasia. Categorical variables were coded using prespecified reference categories. Age and time to admission were analyzed as continuous variables in regression models.

Statistical analysis

All statistical analyses were conducted using SPSS Statistics version 30 (IBM Corp., Armonk, NY, USA). To compare the demographic and clinical data of patients admitted in 2014 and 2024, statistical analyses were performed using both parametric and non-parametric tests, as appropriate. Categorical variables were compared using Pearson's chi-square test. In cases where expected frequencies were below 5, Fisher's exact test was employed. Continuous variables were assessed for normality and subsequently analyzed using independent-samples t-tests for normally distributed data or Mann-Whitney U tests for skewed

distributions.

Change in functional status over time was assessed by FIM gain (discharge total FIM minus admission total FIM), with positive values indicating functional improvement. To identify predictors of FIM gain, generalized linear models were used to examine the association between clinical and demographic variables and FIM gain during inpatient rehabilitation. Separate analyses were conducted for the 2014 and 2024 samples.

Ordinary least-squares linear regression with an identity link and Gaussian error distribution was used. Model fit was summarized using R^2, adjusted R^2, the overall F test, and the residual standard error. Multicollinearity was assessed using tolerance and variance inflation factors (VIFs). Linearity and homoscedasticity were assessed visually using residual-versus-fitted plots. Normality of residuals was assessed using histograms and normal probability plots.

Generalized linear models were fitted to examine whether the associations between the significant predictors and FIM gain differed between 2014 and 2024. This was done by including a year × predictor interaction term in separate models for each predictor.

Missingness was described for each study variable before modelling. No imputation or other missing-data technique was used. Regression analyses were performed using complete-case (listwise) analysis. Thus, participants with missing data in the outcome or any covariate in a given model were excluded from that model. The prespecified FIM-gain model included 217 complete cases (9 of 226 participants excluded). The 2014 model included 132 participants, and the 2024 model included 85 participants. Given the small proportion of excluded observations, complete-case analysis was considered acceptable, but this approach assumes that exclusion did not introduce material selection bias. Model coefficients are presented as unstandardized B values with corresponding standard errors, p-values, and 95% confidence intervals (CIs). Significance was deemed at p-values <0.05.

Results

Comparison of 2014 and 2024 cohorts

A total of 226 patients were included in this study: 138 (61%) in the 2014 cohort and 88 (39%) in the 2024 cohort. Table *1* presents the demographic and clinical differences between patient cohorts (2014 vs 2024). A comparative analysis was conducted across a variety of variables.

Variables	2014 (n = 138)	2024 (n = 88)	Test statistic (effect size)	P-value
Sex				
Male	69 (50.0%)	42 (47.7%)	$\chi^2(1) = 0.111$, $\varphi = 0.022$	0.739 (a)
Female	69 (50.0%)	46 (52.3%)		
Age[1]	60.1 (13.9)	61.8 (13.5)	$t(224) = -0.880$, $d = 0.120$	0.380 (c)
≤65 years	89 (64.5%)	47 (53.4%)	$\chi^2(1) = 2.755$, $\varphi = 0.110$	0.097 (a)
>65 years	49 (35.5%)	41 (46.6%)		
Previous status				
Autonomous	131 (94.9%)	84 (95.5%)	(Fisher) $\varphi = 0.042$	0.715 (b)
Non-autonomous	4 (2.9%)	4 (4.5%)		
NA	3 (2.2%)	0 (0.0%)	-	-
Education				
≤4 years	40 (29.0%)	26 (29.5%)	$\chi^2(1) = 0.107$, $\varphi = 0.022$	0.744 (a)
>4 years	85 (61.6%)	61 (69.3%)		
NA	13 (9.4%)	1 (1.1%)	-	-
Previous stroke				
No	119 (86.2%)	73 (83.0%)	$\chi^2(1) = 0.452$, $\varphi = 0.045$	0.502 (a)
Yes	19 (13.8%)	15 (17.0%)		

Type of stroke				
Ischaemic	94 (68.1%)	68 (77.3%)	$\chi^2(1) = 2.220$, $\varphi = 0.099$	0.136 (a)
Hemorrhagic	44 (31.9%)	20 (22.7%)		
Acute hospital complications				
No	101 (73.2%)	68 (77.3%)	$\chi^2(1) = 0.475$, $\varphi = 0.046$	0.491 (a)
Yes	37 (26.8%)	20 (22.7%)		
Referral				
Hospital	44 (31.9%)	40 (45.5%)	$\chi^2(2) = 15.538$, $V = 0.262$	<0.001*** (a)
Continuing care unit	32 (23.2%)	31 (35.2%)		
Home	62 (44.9%)	17 (19.3%)		
Time to admission[2]	58.0 (44.0-83.0)	94.0 (73.0-133.0)	U = 2855.5, Z = −6.432, r = 0.431	<0.001*** (d)
<3 months	105 (76.1%)	39 (44.3%)	$\chi^2(2) = 21.356$, $V = 0.309$	<0.001*** (a)
3–6 months	25 (18.1%)	32 (36.4%)		
>6 months	8 (5.8%)	14 (15.9%)		
NA	0 (0.0%)	3 (3.4%)	-	-
Length of stay[3]	66.0 (60.0–74.0)	64.5 (60.0–74.0)	U = 5511.0, Z = −1.172, r = 0.078	0.241 (d)
Total FIM score on admission[4]	67.2 (27.9)	72.3 (25.9)	t(224) = −1.377, d = 0.188	0.170 (c)
Severe (<54)	48 (34.8%)	18 (20.5%)	$\chi^2(2) = 5.436$, $V = 0.155$	0.066 (a)
Moderate (54–90)	57 (41.3%)	46 (52.3%)		
Mild (>90)	33 (23.9%)	24 (27.3%)		
Total FIM score at discharge[5]	84.1 (29.5)	86.4 (27.0)	t(224) = −0.578, d = 0.079	0.564 (c)
Severe (<54)	28 (20.3%)	14 (15.9%)	$\chi^2(2) = 1.538$, $V = 0.083$	0.463 (a)
Moderate (54–90)	43 (31.2%)	24 (27.3%)		
Mild (>90)	67 (48.6%)	50 (56.8%)		
FIM gain[6]	16.95 (11.82)	14.10 (8.84)	t(224) = 1.939, d = 0.265	0.054 (c)
Aphasia				
No	82 (59.4%)	56 (63.6%)	$\chi^2(1) = 0.402$, $\varphi = 0.042$	0.526 (a)
Yes	56 (40.6%)	32 (36.4%)		
Neglect				
No	123 (89.1%)	69 (78.4%)	$\chi^2(1) = 4.833$, $\varphi = 0.146$	0.028 *(a)
Yes	15 (10.9%)	19 (21.6%)		
FAC on admission	1.5 (1.6)	1.7 (1.5)	t(219) = −0.658, d = 0.090	0.511 (c)

TABLE 1: Sample comparisons (2014 vs. 2024).

Results are presented as N (%), except for the continuous quantitative variables age, time to admission, length of stay, FIM score on admission, FIM score at discharge, FIM gain, and FAC on admission ([1]mean (SD), in years; [2]median (IQR), in days; [3]median (IQR), in days; [4,5,6,7]mean (SD)). NA categories were not included in the statistical tests. A significance threshold of $p < 0.05$ was adopted.

P-values were computed with (a) Pearson's chi-square test, (b) Fisher's exact test, (c) independent samples t-test, and (d) Mann-Whitney U test. The test statistic column reports, for each test, the chi-square value ($\chi^2(df)$), the t-value (t(df)), or the Mann-Whitney U with its standardized Z value; Fisher's exact test does not produce a test statistic. Effect sizes: phi coefficient (φ) for Pearson's chi-square and Fisher's exact tests in 2 × 2 tables; Cramér's V for Pearson's chi-square tests in tables with more than two categories (referral, time to admission, total FIM score on admission and at discharge); Cohen's d for independent samples t-tests; and point-biserial correlation coefficient $r = |Z|/\sqrt{N}$ for Mann-Whitney U tests. Effect sizes are presented as absolute values. Negative t and Z values indicate lower values in 2014 than in 2024; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

FIM: Functional Independence Measure; FAC: Functional Ambulation Categories; NA: not available

Both groups did not significantly differ in sex distribution, with an equal proportion of males and females in 2014 and a similar pattern in 2024. The average age was also comparable between the two cohorts. When categorized by age group, a non-significant trend toward a higher proportion of patients aged over 65 years was observed in 2024.

Regarding pre-morbid status, most patients in both years were autonomous before the index event, without significant difference. Similarly, no significant differences were found in educational attainment, with almost a third of patients in both cohorts having four or fewer years of education.

The prevalence of previous stroke was slightly higher in 2024, but the difference was not statistically significant. In both cohorts, ischemic stroke was the dominant stroke subtype. The incidence of complications during acute hospitalization remained relatively stable between both years.

Referral source showed a significant shift between the two periods. In 2024, more patients were referred from hospitals and continuing care units, while referrals from home sharply decreased. This was accompanied by a significant increase in time to admission: the median time from event to admission increased from 58 days in 2014 to 94 days in 2024 ($p < 0.001$). When time to admission was categorized, the proportion of patients admitted within three months dropped substantially, while those admitted between three and six months or after that increased. Length of rehabilitation center stay was not significantly different between the two cohorts, with a median of 66 days in 2014 and 64.5 days in 2024.

Total FIM scores on admission were slightly higher in 2024 (mean = 72.3) than in 2014 (mean = 67.2), but this difference was not statistically significant ($p = 0.170$). When FIM on admission was categorized, fewer patients in 2024 presented with severe functional impairment (<54), though the difference did not reach significance. Total FIM scores at discharge were also comparable between both years (84.1 in 2014 vs 86.4 in 2024; $p = 0.564$), and the distribution across severity categories showed no significant differences ($p = 0.463$). FIM gain in 2014 was 16.95 (SD = 11.82), while in 2024, it was 14.10 (SD = 8.84) ($p = 0.054$).

No meaningful differences were found in the prevalence of aphasia between 2014 and 2024. However, neglect was significantly more common in the 2024 cohort. Motor function at admission, measured by FAC, showed no significant differences.

Predictors of functional outcome

Separate prespecified multiple linear regression models were fitted for FIM gain in the 2014 and 2024 cohorts (Table *2*). In 2014, the model was statistically significant, explaining 18.7% of the variance in FIM gain. In 2024, the model was also statistically significant, explaining 26.6% of the variance.

Preditor	2014 B (95% CI)	P-value	2024 B (95% CI)	P-value
Sex (female)	−3.92 (−7.78 to −0.06)	0.047*	−1.44 (−5.23 to 2.35)	0.452
Age (years)	−0.12 (−0.27 to 0.04)	0.140	−0.09 (−0.24 to 0.06)	0.256
Type of stroke (hemorrhagic)	1.92 (−2.43 to 6.27)	0.384	−2.31 (−6.71 to 2.10)	0.300
Time to admission (days)	−0.04 (−0.08 to −0.01)	0.022*	−0.01 (−0.03 to 0.01)	0.221
Referral (hospital)	1.37 (−3.12 to 5.86)	0.546	9.39 (4.29 to 14.49)	<0.001***
Referral (continuing care unit)	0.70 (-4.47; 5.88)	0.789	3.28 (-2.20; 8.76)	0.236
Complications during acute hospitalization	−4.12 (−8.95 to 0.70)	0.093	−4.68 (−9.25 to −0.11)	0.045*
FAC at admission	−1.40 (−2.65 to −0.16)	0.028*	−1.74 (−3.04 to −0.43)	0.010*
Neglect	−1.68 (−8.53 to 5.17)	0.629	−3.90 (−8.36 to 0.57)	0.086
Aphasia	5.00 (1.02 to 8.99)	0.014*	−0.23 (−4.30 to 3.84)	0.910
Complete cases	132	-	85	-
R^2 (R^2 adjusted)	0.187 (0.121)	-	0.266 (0.167)	-
SEE	10.920	-	8.189	-
F (df1, df2)	2.811 (10, 121)	-	2.688 (10, 74)	-
P-value	0.004	-	0.007	-

TABLE 2: Predictors of functional outcome.

Results are presented as unstandardized coefficients (95% CI). A significance threshold of $p < 0.05$ was adopted. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$. P-values were computed with the t-test.

CI: confidence interval; FAC: Functional Ambulation Categories

In 2014, female sex, longer time to admission, and higher FAC at admission were significant predictors of unfavorable outcomes, while the presence of aphasia was a predictor of good outcomes. Complications during acute hospitalization, age, stroke type, referral source, and neglect were not significantly associated with the outcome.

In contrast, the 2024 model identified hospital referral as a strong positive predictor, while complications during hospitalization and higher FAC at admission were associated with poorer outcomes. Neglect, sex, age, stroke type, time to admission, and aphasia were not significant predictors in 2024.

Comparing the two periods, the significant association between FIM gain and sex, time to admission, and aphasia observed in 2014 was no longer present in 2024. Conversely, hospital referral, which was not associated with the outcome in 2014, emerged as the strongest predictor in 2024. Complications during hospitalization also became a significant negative predictor in 2024, whereas they were only marginally associated with the outcome in 2014. Higher functional ambulation at admission (FAC) remained a consistent independent predictor across both cohorts.

Next, we modelled FIM gain based on the significant predictors for each year. For 2014, we included sex (female), time to admission, FAC on admission, and aphasia, resulting in a statistically significant model, explaining 12.9% of the variance in FIM. For 2024, we included hospital referral, complications during hospitalization, and FAC on admission, resulting in a significant model, explicating 16.8% of the variance in FIM gain.

VIFs ranged from 1.060 to 1.362 in 2014 and from 1.105 to 2.187 in 2024. Residual plots, histograms, and normal probability plots were generated, confirming normality. Variance homoscedasticity was established by observing no trend in the residuals vs fitted values plot.

Generalized linear models were fitted to examine whether the associations between the significant predictors and FIM gain differed between 2014 and 2024. This was done by including a year × predictor interaction term in separate models for each predictor. Significant interaction effects were observed for time

to admission and aphasia, whereas no evidence of interaction was found for sex, hospital referral, complications during hospitalization, or FAC on admission.

A significant year × time to admission interaction was identified (B = 0.04, 95% CI = 0.00 to 0.08, p = 0.041), indicating that the association between time to admission and FIM gain differed between 2014 and 2024. In 2014, longer time to admission was associated with lower FIM gain (B = −0.05, 95% CI = −0.07 to −0.02, p = 0.003), whereas this association was substantially attenuated in 2024 (estimated slope = −0.01 points/day).

Similarly, a significant year × aphasia interaction was observed (B = −6.44, 95% CI = −12.25 to −0.62, p = 0.030), indicating that the association between aphasia and FIM gain differed between the two cohorts. In 2014, patients with aphasia had higher FIM gain than those without aphasia (B = 4.65, 95% CI = 1.07 to 8.24, p = 0.011), whereas this association was reversed in 2024 (estimated effect = −1.78 points).

No significant interactions were found between year and sex (B = 2.33, 95% CI = −3.36 to 8.01, p = 0.423), hospital referral (B = 4.24, 95% CI = −1.58 to 10.06, p = 0.153), complications during hospitalization (B = 1.66, 95% CI = −4.92 to 8.24, p = 0.621), or FAC on admission (B = −0.15, 95% CI = −1.98 to 1.67, p = 0.869), indicating that the associations between these variables and FIM gain did not differ significantly between 2014 and 2024.

Discussion

The samples from both years were similar with respect to sex, prior functional autonomy, and mean age, although the proportion of patients aged over 65 years was higher in 2024. Over the 10-year period, the referral pattern changed, with a shift from community-based referrals toward acute hospitals. This was accompanied by a longer interval between stroke onset and admission to the rehabilitation center in 2024. Despite these disparities, no statistically significant difference was detected in admission and discharge FIM scores between cohorts.

The present findings are broadly consistent with the established view that functional recovery after stroke is multifactorial. Previous studies have identified admission functional status, stroke severity, age, aphasia, neglect, and other neurological and clinical characteristics as relevant predictors of functional outcome after inpatient stroke rehabilitation [5,7-9]. A systematic review of multivariable prognostic models similarly identified admission functional status, NIHSS, dysphasia, neglect, previous stroke, and age among the variables most frequently associated with functional outcome [9]. Our study therefore supports the importance of considering multiple dimensions of the patient's clinical and functional status rather than relying on a single prognostic factor.

In 2014, a longer interval between stroke onset and rehabilitation admission was associated with lower functional gain. This finding is consistent with previous studies reporting better functional improvement among patients admitted earlier to inpatient rehabilitation [8,11]. Wang et al. found that shorter time from stroke onset to rehabilitation admission was associated with greater FIM gains after adjustment for demographic, medical, and functional characteristics [11]. The relationship between timing of rehabilitation admission and outcome may, however, also reflect differences in patient characteristics and clinical pathways leading to rehabilitation. In our cohort, the longer admission interval observed in 2024 occurred alongside a marked change in referral patterns, suggesting that differences in the timing of admission may be partly related to changes in the pathway through which patients reached the rehabilitation center.

The finding that aphasia was associated with greater FIM gain in 2014 differs from the literature, in which aphasia is generally associated with poorer functional prognosis after stroke [5,7-9]. One possible explanation is that substantial language recovery may occur during the first six months after stroke, particularly during the earlier post-stroke period [15]. This may have contributed to the greater functional gains observed among patients with aphasia in the 2014 cohort. Importantly, approximately three-quarters of patients in 2014 were admitted within three months of stroke, compared with approximately 40% in 2024. The earlier timing of rehabilitation in 2014 may therefore have allowed greater recovery of language and related functional abilities during the rehabilitation period. Nevertheless, this finding should be interpreted cautiously, as the association was observed only in the 2014 cohort and may also reflect differences in patient selection or unmeasured clinical characteristics.

The association between higher FAC at admission and lower FIM gain in both cohorts also warrants careful consideration. At first sight, this finding appears counterintuitive, as better ambulatory function would generally be expected to be associated with better functional status. However, FAC primarily captures ambulatory ability and does not comprehensively assess cognitive or behavioral impairment. Furthermore, patients with better mobility at admission may have had less room for improvement in the motor components of the FIM. Because the outcome in our study was based on total FIM rather than separate motor and cognitive domains, the observed association between FAC and FIM gain may partly reflect differences between the domains captured by these measures.

In 2024, hospital referral was associated with greater FIM gain, whereas acute hospital complications were

associated with lower gain. These associations may reflect differences in clinical complexity, timing of referral, and patient selection. In particular, referral source should not be interpreted as a direct causal determinant of recovery, but rather as a potential marker of the clinical pathway and characteristics of patients reaching inpatient rehabilitation. Similarly, acute hospital complications may reflect greater medical complexity or stroke severity, variables that were not fully captured in the available records.

The differences in predictors between 2014 and 2024 may therefore reflect differences in patient characteristics and rehabilitation pathways rather than a fundamental change in the determinants of stroke recovery.

The absence of a statistically significant difference in FIM gain between the two groups should be interpreted with caution. Although this may suggest that patients selected for inpatient rehabilitation achieved broadly similar functional improvement in 2014 and 2024, it does not establish that rehabilitation effectiveness remained unchanged over the 10-year period. Differences in referral pathways, timing of admission, and patient selection may have influenced the composition of the two cohorts. In addition, relevant prognostic variables, including stroke severity, NIHSS score, lesion characteristics, and acute-phase treatment, were not available in the clinical records. These limitations make it difficult to determine whether the observed differences in predictors reflect changes in the prognostic factors themselves or differences in the patients admitted for rehabilitation. The exclusion of patients unable to participate in an intensive inpatient rehabilitation program may also have introduced selection bias and limited the generalizability of the findings to patients with more severe disability or medical complexity.

Overall, the present findings reinforce the multifactorial nature of functional recovery after stroke and highlight the importance of considering both patient characteristics and the pathway to rehabilitation when interpreting functional outcomes. Future prospective studies incorporating standardized measures of stroke severity, lesion characteristics, cognitive and behavioral impairment, acute treatment, long-term outcomes, and larger sample sizes are needed to better characterize the determinants of recovery after stroke.

Conclusions

The absence of a statistically significant difference in FIM gain over the 10-year period should be interpreted with caution, as this does not necessarily imply comparable outcomes or equivalent rehabilitation effectiveness. The findings suggest that functional recovery after stroke is multifactorial and that the factors associated with functional improvement may vary over time and according to the clinical and functional characteristics of patients admitted for rehabilitation. They should be interpreted in the context of differences in patient selection and referral patterns between the two periods. The retrospective design and the absence of relevant measures of stroke severity, lesion characteristics, and acute treatment limit causal inference and generalizability. Prospective studies incorporating these factors, together with long-term outcomes and larger sample sizes, are warranted to further clarify the determinants of functional recovery after stroke.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

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