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ORIGINAL ARTICLE

The Minimal assessment Protocol for Cerebral Stroke 2020 (PMIC2020): a multicenter feasibility study in post-stroke inpatient rehabilitation

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ABSTRACT

BACKGROUND: In 2008, a Working Group of the Italian Society of Physical and Rehabilitation Medicine (SIMFER) published the first minimum protocol for assessing stroke patients (PMIC) to define functional needs and outcomes. The recent PMIC revision (PMIC2020) introduces a document for all rehabilitation settings, incorporating updated measurement tools.
AIM: The aim of this study was to investigate the PMIC2020 feasibility and administration time (AT) in post-stroke inpatients and to examine the influence of demographic and clinical variables on AT.
DESIGN: Multicenter prospective observational study.
SETTING: Eight Italian rehabilitation centers for post-acute inpatients.
POPULATION: Adult patients consecutively admitted to rehabilitation after ischemic/hemorrhagic stroke, reporting the first event or recurrence, with a modified Barthel Index (mBI)<75 points, without cognitive impairment and clinical instability.
METHODS: PMIC2020 was administered at admission (T0) and discharge (T1), recording AT of each section/ tool. A feasibility questionnaire was administered to assessors. Univariate and multivariate analyses were conducted to investigate the effect of demographics and clinical variables on AT.
RESULTS: One hundred fifty-one subjects were enrolled at T0 and 139 at T1; the mean±SD AT (seconds) was 1634±401 at T0 and 1087±360 at T1 (P<0.001). National Institute of Health-Stroke Scale and Mini-Mental State Examination required the highest AT. All but two scales had significantly lower AT at T1 (P<0.05). Severe disability (as measured by mBI) was associated with higher AT than either complete or minimal/ absent disability. The feasibility questionnaire showed good PMIC2020 appraisal by assessors without relevant critical issues.
CONCLUSIONS: PMIC2020 was feasible in post-acute inpatient rehabilitation settings. No relevant critical issue was raised by users. Even though more comprehensive than PMIC, PMIC2020 required only slightly more AT (27 minutes at T0 and 18 minutes at T1, on average); more AT was needed to assess patients with severe disability.
CLINICAL REHABILITATION IMPACT: The study has immediate transferability for the National Health Service, as PMIC2020 can be routinely implemented in clinical practice and research to assess stroke patients' needs and outcomes. The updated measures allow more immediate

comparisons with international data on stroke rehabilitation. Future research should investigate the PMIC2020 feasibility in other rehabilitation settings and its relevance in predicting stroke rehabilitation needs and outcomes.

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KEY WORDS: Stroke; Rehabilitation; Patient outcome assessment; Rehabilitation Centers.

Following the innovation in hyperacute phase treatments, there has been a commendable 20% reduction in age-standardized stroke mortality for ischemic stroke and 25% for hemorrhagic stroke.[1] However, in western countries, stroke and its consequences are increasingly challenging to manage despite these advances. In 2017, there were 1.12 million incident strokes in the European Union, with 9.53 million stroke survivors, and the prevalence of stroke survivors in the general population is rising due to an aging demographic and decreased mortality.[1] Many stroke survivors have problems with mobility, fatigue, speech, memory, and/or emotions, and need support from one or more rehabilitation professions, such as physical therapy, speech therapy, occupational therapy, and/or psychological support.[1] However, there is no evidence that post-stroke rehabilitation is more effective than before.[2] Consequently, disabling outcomes after stroke persist, producing an impact on functions, activity, participation, and on quality of life of stroke survivors, and often of their families, thus presenting a significant health and social issue.[1, 3]

For rehabilitation medicine, the care and treatment of patients and their families pose major challenges at the clinical and organizational levels. Presently, approximately one-third of survivors experience significant disability,[2, 3] necessitating specific rehabilitation treatments in the acute and post-acute phases, often in inpatient settings and extending to the long term.

Stroke rehabilitation aims not only at sensory-motor impairment but addresses all stroke sequelae, including pain, depression, cognitive issues, communication, speech, swallowing, sphincter, and respiratory problems.[4, 5] Moreover, the aging population influences short- and long-term clinical, rehabilitation, and care needs, along with a spectrum of psychosocial problems during community reintegration. Thus, assessing the multidimensional needs of stroke patients is a critical aspect of rehabilitation intake, and of developing the Individual Rehabilitation Project (IRP), which should be comprehensive, easily applicable in different settings, and shareable by the rehabilitation team.

From a European perspective, the Stroke Alliance For Europe (SAFE) recently recommended that the European Commission and the Joint Research Centre should support and promote, at the European level, the development of tools to assess prevention and treatment needs and the quality of care throughout the stroke pathway.[1]

In 2004, the Italian Society of Physical Medicine and Rehabilitation (SIMFER) formed a working group to draft the first version of a minimal protocol assessing the prevention and care needs of stroke patients from the acute in-hospital phase to returning home. The aim was to enable local comparisons, share data governance, and collect constantly updated data for clinical, epidemiological, and programmatic purposes. The Minimal Assessment Protocol for Cerebral Stroke (PMIC)[6] was published in 2008 and proved to be rapidly administered.[7, 8] However, issues emerged over time in its daily use, including the need to revise the chosen tools. This prompted SIMFER to form a new working group that revised and produced an updated version, PMIC2020, recently published.[9, 10] PMIC2020 is designed to provide every rehabilitation team with a uniform and feasible tool for evaluating stroke patients from acute hospital to territorial rehabilitation, addressing prevention, treatment needs, and care quality.

PMIC2020 aims to standardize assessments for better comparisons and governance of care processes in Italy and globally, taking into account information value, minimal time requirements, applicability in various settings, data availability, and validated tools, preferably in their Italian version. PMIC2020 is based on the International Classification of Functioning, Disability, and Health (ICF)[10] and the most up-to-date guidelines.[2, 11]

The assessment domains were organized to develop an outcome-oriented IRP,[12] covering clinical stability, basic life functions, communicative-relational, cognitive-behavioral impairments, sensory-motor impairments, mobility and transfers, autonomy in daily activities, and social adaptation and reintegration. Unlike the previous PMIC version, the current protocol is a unified three-section document. The first section collects demographic and anam-

nestic information, such as age, gender, and level of education, at the first patient contact, regardless of the assessment setting. The second part comprises clinical data on the stroke and interventions performed in the acute setting. The third part includes clinical assessment using validated tools applicable at different stages and settings, repeatable as needed for patient monitoring. Some dimensions, as pain, lower limb function, and participation, were further investigated with new tools while existing tools were updated based on recent literature.[9, 10]

The primary objective of this multicenter study is to investigate the feasibility of PMIC2020 in stroke patients admitted to intensive rehabilitation inpatient units. The primary endpoint is the administration time (AT). The secondary objective is to explore the influence of demographics and clinical variables on the AT of PMIC2020.

Materials and methods

This multicenter observational study involved eight Italian rehabilitation centers: IRCCS San Raffaele, Rome (coordinator center); Neuromotor Rehabilitation 0 and 1 Units, IRCCS Fondazione Don Carlo Gnocchi, Florence; Intensive Neuromotor Rehabilitation Unit, U.S.L. Umbria 2, Trevi; Rehabilitation Medicine-Cerebral Palsy Unit, University Hospital Agency, Ferrara; Spinal Unit, Neurorehabilitation and Intensive Rehabilitation Medicine, Local Health Agency, Piacenza; Neurological Rehabilitation Unit, IRCCS Fondazione S. Lucia, Rome; Neurological Rehabilitation Unit, Baggiovara Hospital, Local Health Agency, Modena; Passignano sul Trasimeno Intensive Rehabilitation Hospital, Local Health Agency Umbria 1. The Ethics Committees of all Centres involved approved the protocol (coordinator centre Ethical Committee Approval Number: RP E/21/54).

Participants

To obtain data comparable to the previous feasibility studies on the original PMIC,[7, 8] we set a sample size of at least 100 patients to be recruited among subjects admitted to the centers involved. Patients addressing these centers for post-acute inpatient rehabilitation from July 2022 to September 2023 were consecutively assessed for eligibility and were enrolled, provided they met the following inclusion criteria: ischemic or hemorrhagic stroke (first event or with recurrence), age greater than 18 years, presence of mild-moderate to complete disability (modified Barthel Index [mBI] <75 points),[13] willingness to participate with signed informed consent. To obtain data on the whole PMIC2020 administration, subjects with severe cognitive impairment and/or who could not collaborate in the assessment were excluded, based on clinical evaluation. Included patients could drop out of the study at any time for the following reasons: the desire to leave the study, refusal to cooperate with the study investigators or a medical condition that, in the opinion of the investigator, contraindicated the continuation of the study.

Measures

PMIC2020 requires the recording of a minimum set of variables/measures comprising demographic and anamnestic information, which should be collected at the first contact with the person with stroke, and that of clinical data and assessment tools, which can be used at different stages of the disease and in other settings where interventions are delivered. According to the ICF model, the domains of functioning were explored with the following measurement tools:

• contextual factors: education, occupation, native language, family and caregiver support, disability certification, current housing, architectural barriers;

• structures and functions: affected side, stroke etiology and classification (Oxfordshire Community Stroke Project [OCSP] for ischemic stroke); thrombolysis/thrombectomy procedures; Body Mass Index [BMI] (obesity: MBI >30; malnutrition: BMI <18); breathing; swallowing; urinary and fecal continence; pain (Numeric Rating Scale [NRS] – replacing the Visual Analogue Scale[14] – and the Pain Assessment in Advanced Dementia Scale [PAINAD] – newly introduced variable to assess pain in the nonverbal patient[15]); spasticity (measured as present/absent for each joint district instead of the Modified Ashworth Scale [MAS][16]); trunk control (Trunk Control Test [TCT][17]); motricity (Motricity Index [MI][18]); cognitive status (Mini-Mental State Examination [MMSE][19]); neurological impairment (National Institute of Health Stroke Scale [NIHSS],[20] replacing the Canadian Neurological Scale[21]); mood (adequate/deficit/not assessable) – newly introduced variable;

• activity: anamnestic and current degree of disability (modified Rankin scale [mRS][22]); lower extremity performance and frailty (Short Physical Performance Battery [SPPB][23] – newly introduced variable), ambulation (Functional Ambulation Classification [FAC][24]); basic activities of daily living (modified Barthel Index [mBI],[13] replacing the Barthel Index[25]);

• participation (only at admission): walking/mobility (modified Functional Walking Categories, previously

named Walking Handicap Scale [WHS][26]); involvement in community, instrumental, and leisure activities (Frenchay Activities Index [FAI][27] – newly introduced variable).

A detailed description of the instructions for administering each instrument in Italian is available online.[9]

This study also aims to provide a feasibility assessment of the PMIC2020 by administering a semi-structured questionnaire to the assessors involved in all centres. The questionnaire investigated any issue encountered in administration, and a measure of appraisal of the PMIC2020 on a 0-5 points NRS.

Procedures

Participating centers identified assessors to administer the PMIC2020 to patients admitted to their wards. All PMIC2020 administrations were performed according to the instructions reported in a previous article[9] to share homogeneous administration methods and minimize any bias in recording times following evaluations. Moreover, a web-based discussion phase was conducted to explain in detail the PMIC2020, how the instruments are administered, and agree on uniform modes of behavior. It was agreed that all assessments should be performed within three days from admission (T0) into rehabilitation and no more than three days prior to discharge (T1). The PMIC2020 administration needed to be completed within 24 hours from its start. Each center identified at least two assessors who performed all study evaluations.

Assessors recorded the partial AT of the single parts of the PMIC2020 (socio-demographic and anamnestic part and individual scales) as well as the total AT.

Data analysis

Data were summarized as mean and standard deviation (SD), median and interquartile range, or frequency with absolute percentages, as appropriate. Paired *t*-tests were used to compare the AT for both the total time and the time for each part of the PMIC2020, required at admission and discharge. Since some variables were collected only at T0 (anamnestic information, WHS, and FAI), the total time at T0 was also computed excluding these variables.

Both univariate and multivariate analyses were conducted to explore the effect on AT of demographic and clinical variables, including age, gender, stroke severity (as measured by NIHSS), stroke type (ischemic/hemorrhagic), time since the acute event, pre-stroke disability (as measured by the anamnestic mRS), and severity of disability at T0 and T1 (as measured by the mRS and the mBI). First, the association of each variable with the AT of PMIC2020 was explored by calculating the Pearson (continuous variables) or the Spearman (ordinal variables) coefficients at both T0 and T1. Univariate ANOVA was used to test for differences in AT according to stroke type (ischemic, hemorrhagic) and distance from stroke, classified into three categories (within 15 days, 15 to 30 days, and over 30 days). Linear regression models were then applied, considering the AT as the dependent variable and the clinical and demographic variables significantly associated with the AT in the univariate analysis as independent variables. To further explore the effect of disability severity on AT, participants were grouped according to the mBI score with the criteria adopted by Chen *et al.*,[28] who considered six classes of disability: 0-24 (complete disability), 25-49 (severe disability), 50-74 (moderate disability), 75-90 (mild disability), 91-99 (minimal disability), and 100 (no disability) points. For this study, however, the last two classes were combined into a single category (91-100, minimal or no disability. The ANOVA with Tukey Post-Hoc Test was used to identify differences among groups.

Statistical analysis

The statistical analysis was performed with the JASP computer software, version 0.18.1 (JASP Team, 2023). For all comparisons, statistical significance was set at $P<0.05$.

Results

Participants

The study included 151 subjects at T0 and 139 at T1. Twelve subjects were lost at T1 due to complications (8 participants transferred to an acute ward) or unplanned discharge (4 patients). The PMIC2020 was administered to all enrolled patients according to the protocol schedule, with the exception of patients who were lost at discharge assessment. Demographic and clinical characteristics of the sample are reported in Table I, II, respectively. The sample mostly comprised older subjects (mean age=70.8±10.3 years) with almost two-thirds being men. Most participants were non-employed or retired due to their advanced age. While only two subjects lived with a formal caregiver, about two-thirds had a part-time caregiver. Over half of the subjects reported architectural barriers at home.

Approximately 4/5 of the participants had an ischemic stroke, and the affected side was evenly distributed between the right and left sides. Stroke severity, according to NIHSS, was mostly minor or moderate, but comorbidities, particularly cardiac and less frequently dysmetabolic,

TABLE I.—*Characteristics and provenance of included subjects (N.=151).*

Gender	
Male	95 (62.9)
Female	56 (37.1)
Age in years, mean (SD), range	70.8 (12.3), 40-96
Working condition	
Employed	42 (27.8)
Not employed/retired	109 (72.2)
Living together	
Alone	43 (28.5)
Relatives	106 (70.2)
Caregiver	2 (1.3)
Caregiver, including part-time caregiver	
Yes	97 (64.2)
No	54 (35.8)
Architectural barriers at home	
Yes	91 (60.3)
No	58 (38.4)
Not recorded	2 (1,3)

Data are shown as frequency (percentage) unless specified.
SD: standard deviation.

TABLE II.—*Clinical data of included subjects (N=151). Data are shown as frequency (percentage) unless specified.*

Type of stroke	
Ischemic	116 (76.8)
Hemorrhagic	35 (23.2)
Side of paresis	
Right	72 (47.7)
Left	74 (49.0)
Bilateral	5 (3.3)
Time since stroke (days)	
0-15	75 (49.7)
16-30	60 (39.7)
31-120	12 (7.9)
>120	4 (2.6)
Stroke severity	
NIHSS score, mean(SD)	8.0 (5.1)
Minor (NIHSS<5 points)	43 (28.5)
Moderate (NIHSS 5-15 points)	92 (60.9)
Moderate/severe (NIHSS 16-20 points)	15 (9.9)
Severe (NIHSS>20 points)	1 (0.7)
Presence of spasticity	
Upper limb	41 (27.2)
Lower limb	29 (19.2)
Presence of comorbidities	
Cardiac	123 (81.5)
Respiratory	28 (18.5)
Infectious	12 (7.9)
Neoplastic	21 (13.9)
Neurological	24 (15.9)
Psychiatric	6 (4.0)
Orthopedic	33 (21.9)
Dysmetabolic	82 (54.3)
Pre-stroke disability (mRS>0 points)	
Yes	52 (34.4)
No	99 (65.6)
Length of stay in days, mean (SD)	49.6 (30.1)

NIHSS: National Institute of Health Stroke Scale; mRS: modified Rankin Scale.

were common. About one-third of participants had some pre-stroke disability. The mean length of stay was 49,6 (SD=30.1) days. In all centers, the same evaluators conducted assessments at T0 and T1, collecting anamnestic and demographic details, stroke type, NIHSS, MMSE, NRS for pain, and mood evaluation.

Administration times

The mean±SD AT at T0 was 1634±401 seconds (approx. 27±7 minutes) in the entire sample. Considering participants (N=139) reassessed at discharge, the total AT for the PMIC2020 assessment was significantly higher at T0 than at T1 (1642±405 and 1087±360 seconds, or approx. 27±7 and 18±6 minutes, respectively; P<0.001). Subtracting the time needed for anamnestic variables at T0 reduced the total time to 1167±317 seconds (approx. 19±5 minutes), but the difference compared to T1 remained significant (P=0.028). Figure 1 illustrates the average AT for each scale/test; all took more time at admission than at discharge except for the SPPB and the FAC. The scales requiring the longest AT at both assessments were the MMSE and the NIHSS, averaging about five minutes.

No associations were found between total AT and any variables at T0, except for the anamnestic (pre-stroke) mRS (rho=0.211; P=0.010). At T0, the total AT was higher in ischemic (1667±250 seconds – approx. 28±4 minutes) than in hemorrhagic (1525±351 seconds – approx. 25±6 minutes) strokes, but the difference was not significant (P=0.066). Regression analysis indicated that mRS ex-

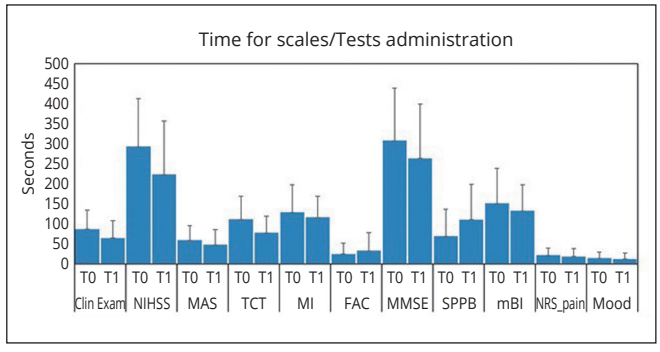

Figure 1.—Mean and standard deviation of the time required for administration of clinical tests/scales at admission (T0) and discharge (T1) (Data from 139 participants who were assessed on both occasions).
Clin Exam: clinical examination; NIHSS: National Institute of Health Stroke Scale; MAS: Modified Ashworth Scale; TCT: Trunk Control Test; MI: Motricity Index; FAC: Functional Ambulation Category; MMSE: Mini Mental State Examination; SPPB: Summary Performance Physical Battery; mBI: modified Barthel Index; NRS_pain: Numerical Rating Scale 0-10 for pain; Mood: mood examination.

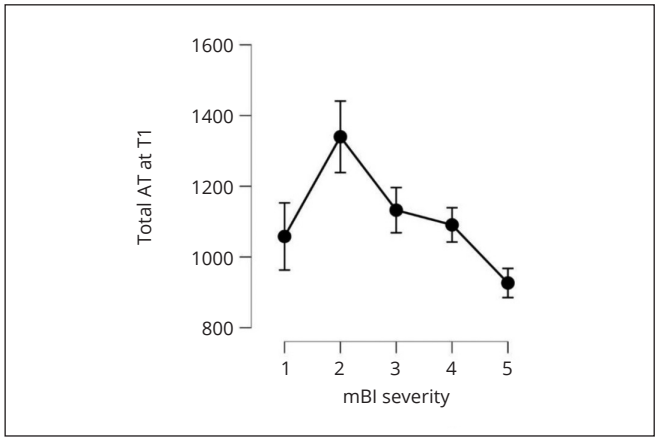

Figure 2.—Mean and standard error of the total time required for administration of PMIC2020 at discharge (total AT at T1) in subgroups of participants with different levels of disability according to modified Barthel Index (mBI) Score.
1: complete disability; 2: severe disability; 3: moderate disability; 4: mild disability; 5: minimal or no disability.

plained a negligible part of the variance in AT (R=0.166; R^2=0.028; adjusted R^2=0.021). Conversely, at T1, total AT significantly (P<0.001) correlated with NIHSS (rho=0.357), mRS (rho=0.364), and mBI (rho=-0.375), with no differences in AT by stroke type. Only mRS remained independently associated with AT (P=0.049) in the multivariate analysis, explaining a very small part of the variance in AT (R=0.341; R^2=0.116; adjusted R^2=0.097).

Regarding the effect of grouping participants by disability severity, no differences were found among groups at T0, but when all participants had complete to moderate disability. All five groups were represented at T1, and the analysis showed significant differences in AT between them (P<0.001), with the group with severe disability taking longer on average than the others (Figure 2). In the *post-hoc* analysis, the difference was significant compared to the groups with minimal to no (P<0.001) or with mild (P=0.032) disability and almost significant compared to the group with complete disability (P=0.058).

Qualitative semi-structured questionnaire

All centers completed the questionnaire exploring qualitative aspects of the research. The questionnaire was answered by the professional(s) conducting the evaluation. As for critical issues, one center noted difficulties related to SPPB instructions, clarified in a dedicated call, while three centers reported "organizational" issues within the department, such as a lack of time for assessment or communication about patients' admission/discharge dates. Only two centers reported poor acceptance by few patients who refused the evaluation. The PMIC2020 tool was rated as "Good" (7 centers) or "Very Good" (1 center). All centers stated that participation in the study helped improve their skills in rehabilitation research. For six centers, the study also contributed to improving their ability to evaluate stroke patients, while for two centers, it did not add value to what was already being done routinely.

Discussion

In 2008, the PMIC[6] was published. Subsequent studies investigated its practical application in two[7] and three[8] Italian inpatient rehabilitation units. The primary aim of those studies was to collect information about the overall applicability of the PMIC. Still, the authors also reported the total AT of the instrument as a secondary finding. In the first study,[7] the PMIC was applied at both admission and discharge, with an average AT of 16.15 minutes reported, without distinction between the two occasions. In the second,[8] patients were assessed with PMIC only upon admission, taking about 20-30 minutes. In this study, we found an average AT of the PMIC2020 of about 27 minutes at admission and 18 minutes at discharge (an average time considering both assessments of 22.5 minutes), slightly higher than those in the first study and in line with the second study. This slight increase in AT might depend on some differences between the original PMIC and the PMIC2020.

In the PMIC2020, several changes were made to update the included outcome measures.[9, 10] The first change to the original PMIC was to replace the Canadian Neurological Scale[21] with the NIHSS.[20] This should not explain the relative increase in AT, since both scales have been reported to take less than ten minutes.[20, 21] Time-consuming evaluation tools, such as the Oxford Cognitive Screening,[29] were not included to keep the protocol relatively quick. For cognitive function, the PMIC2020 retains the Mini-Mental State Examination (MMSE) but also refers to the specific NIHSS Items. Regarding spasticity, the MAS was replaced by a simplified dichotomic spasticity assessment (yes/no) for all body segments included in the MAS. For pain assessment, a simple and validated nonverbal scale frequently used in stroke (PAINAD)[15] was added to the verbal NRS for cases of verbal communication difficulties (*e.g.*, severe speech impairment). Other instruments included in the PMIC2020 but not in the original PMIC are the FAI, the SPPB, and mood evaluation. Their administration took about 5 minutes, which approximately amounts to the additional time required by PMIC2020 in

this study, compared to the original PMIC in the study of Pratesi *et al*.[7] Replacing the original Barthel Index with the mBI might also slightly increase the total AT, as might the introduction of a pain assessment measure specifically designed for individuals with communication disorders. Considering all these changes, our study allows us to compare the AT of PMIC and PMIC2020 and provides novel information about the feasibility of the latter in the setting of inpatient rehabilitation.

Many of the questions and tools included in the PMIC2020 can be administered only if the patient is collaborating (otherwise they take no time, as they are rated 0 or not applicable). Rather than providing clinical-epidemiological information on the whole cohort of patients addressing post-acute inpatient rehabilitation, our study aim was to verify whether the revised PMIC2020, which includes some additional tools, remains still feasible, mainly in terms of AT, both as a whole and considering the time needed for each tool. Thus, we excluded severely impaired patients who could not collaborate to assessment, based on clinical evaluation. This may be considered as a study limitation, as not all stroke patients were assessed with the PMIC, and not all centers recorded the number of those excluded for such reasons. On the other hand, our choice limited the bias of finding shorter average ATs by including subjects to whom most of the instruments could not be administered, and thus resulting in a significant rate of missing data on the AT of some instruments.

This study enrolled more participants and rehabilitation centers than the previous studies on the original PMIC,[7, 8] confirming the applicability of the new protocol in the clinical routine. Indeed, we included a prospective cohort of 151 stroke patients at admission, with less than 10% dropouts at T1, none of them caused by participants' refusal to continue the study.

The characteristics of our study population are comparable with those reported in the literature. Age was analogous to a similar larger Italian cohort.[30] Although some studies have shown more extreme average age values, a systematic review on discharge destination after inpatient stroke rehabilitation found that the mean age of participants ranged from 61.9 to 80.8 years old.[31] Female prevalence is also in line with percentages varying from 35 to 62%.[31] As expected, ischemic stroke represents the vast majority of cases (around 77%), reflecting the usual distribution of the underlying pathogenesis.[32] In our cohort, stroke severity was, on average, about the same as that reported by Scrutinio *et al.* in a larger cohort of stroke patients admitted to an Italian rehabilitation centre.[30]

We found that the AT of the PMIC2020 was significantly higher at admission than at discharge. The difference is partly because some variables (anamnestic information, including FAI and WHS) were collected only at admission. However, the difference was still significant when subtracting the time needed to collect these variables. This may be related to the overall functional improvement registered from admission (T0) to discharge (T1) in our study cohort, with several persons shifting from complete/severe (T0) to mild or even minimal-to-no disability (T1). Indeed, persons with mild or minimal-to-no disability (mBI≥75 points) were not enrolled in this study due to exclusion criteria, while, at T1, they represented about half of the participants. Most likely, this accounts for the reduced AT at T1, since participants having severe disability (mBI score 25-49 points), who required significantly more time to complete the assessments both at T0 and T1, represented 34.8% of the whole sample at T0, and only 17.4% of the sample at T1.

All the outcome measures adopted in the PMIC2020 required, on average, more time at admission than at discharge, except for the SPPB and the FAC. The reason why the SPPB took longer is most likely related to the fact that most patients were addressed to inpatient rehabilitation a few days after the stroke when they had not attempted full stance. Thus, the SPPB was not executable, and the corresponding AT scored 0. Conversely, most patients could undergo the SPPB assessment at discharge, increasing the average time for its administration at T1. The AT reduction from admittance to discharge was always significant except for the FAC, NRS pain, and mood evaluation, probably because all these tools required already a minimal AT at admission. The scales requiring the longest administration AT at both assessments were the MMSE and the NIHSS, which took about 5 minutes on average. A previous study reported an average AT of 7 minutes for the MMSE for stroke patients;[28] thus, our AT aligns with previous literature.

We found no relationship between the AT and the other variables in the multivariate analyses, except for the anamnestic mRS at T0 and the current mRS at T1. In both cases, however, the model explained a very small portion of the variance in AT, indicating that other, possibly individual-related, characteristics play a more relevant role. The differences among subgroups based on the mBI score, however, suggest that individuals with severe disability require more time than the others. This finding was expected and is most likely due to the impossibility of administering part of the scales/tests in those more impaired (*e.g.*, the SPPB), on the one hand, and the other, the reduced time to administer some items, such as MI and MMSE when the

patient has only a minor disability. However, this result must be confirmed in future studies.

The results of the questionnaire highlighted a very active participation of the centers' professionals, who not only carried out the evaluations but who, with their comments, contributed to pointing out critical aspects and suggestions that will allow the tool to be improved. First, it should be noted that the PMIC2020 has proven to be a good evaluation tool in six of the eight involved centers. Each center, based on its organization and skills, was able to identify the active professionals for the minimum assessment. The satisfaction reported by assessors was high, although there were reports of critical issues with some instruments, whose administration methods will need to be reviewed by improving the instruction manual. Some participants expressed the need for an organization of the work context that must include a shared planning of patient admission and discharge times and allow the necessary time for the evaluation. Finally, the unanimous responses from all centers that participation in the PMIC2020 study contributed to improving their skills in the field of rehabilitation research are very relevant, as one of the aims of the PMIC was also to enhance the culture of research among professionals, and provide evidence to the many questions that remain open, including the feasibility and informative value of PMIC2020 in the outpatient setting. Indeed, the routine use of a comprehensive tool, including the most updated international stroke assessment measures, may also have a relevant impact on each assessor's and each rehabilitation center's ability to understand and rate their performance, and allow a quality benchmarking of the rehabilitation care provided to patients addressing stroke rehabilitation among different centers. Further, the PMIC2020 adoption could provide the ground for a European action towards the development of a set of tools to assess prevention and treatment needs, as well as rehabilitation outcomes throughout the stroke pathway at the European level, as recommended by the SAFE.[1]

While future research will investigate the feasibility of the PMIC2020 in other rehabilitation settings and its relevance in predicting stroke rehabilitation needs and outcomes, our results already encourage the routine implementation of the PMIC2020 for clinical and research practice in the inpatient rehabilitation setting.

Conclusions

PMIC2020 was successfully implemented in eight Italian centers providing post-acute inpatient rehabilitation, with no reports of major critical issues. It was overall appreciated by the involved assessors. Although some participants expressed the need to reorganize the work context to allow sufficient time for the assessment, PMIC2020 proved feasible, with average ATs of 27 minutes at T0 reduced to 18 minutes at T1. Compared with the previous PMIC, PMIC2020 required only a slightly longer AT, mainly due to the newly introduced variables deemed necessary for a more comprehensive evaluation. ATs were, on average, longer in patients with severe disability than in patients with complete, mild, or minimal disability. The study's findings hold immediate relevance for the National Health Service, as PMIC2020 can be readily employed in clinical practice and research to evaluate stroke patients' needs and outcomes.

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Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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