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ORIGINAL ARTICLE

The integration of the Italian Rehabilitation Complexity Scale in the assessment of patients admitted to different levels of care in public and private accredited settings and belonging to the main rehabilitative MDCs: a national experience

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ABSTRACT

BACKGROUND: The Italian version of Rehabilitation Complexity Scale-Extended v13 (RCS-E v13) introduced the possibility to objectively assessing rehabilitation patients' needs in terms of clinical complexity integrating tools to assess disability and comorbidity in Italy.
AIMS: To evaluate the contribution of RCS-E v13 in combination with Barthel Index and Cumulative Illness Rating Scale in profiling patients at admission in intensive rehabilitation (IR), extensive rehabilitation (ER) and highly specialized post-acute rehabilitation (HSR).
DESIGN: Observational multicenter prospective cross-sectional study.
SETTING: Adult patients admitted to 25 Italian Rehabilitation accredited facilities both public and private in eight different regions.
POPULATION: Overall, 2809 subjects were included (2454 in IR; 333 in HSR and 22 in ER).
RESULTS: Only IR and HSR data were analyzed since the paucity of ER data. Spearman correlation showed a strong association between RCS-E v13 and BI (ρ=-0.61) and weak correlation with CIRS total score (ρ=0.36 and 0.32), SI (ρ=0.35 and 0.29) and CI (ρ=0.30 and 0.27). EFA revealed two factors (85% variance; KMO=0.747; P<0.001): Factor 1 (CIRS) weakly correlated with LoS (ρ=0.219), Factor 2 (RCS, BI) strongly (ρ=0.677). RCS-Ev13 and BI predicted rehabilitation LoS, with their interaction significantly improving model fit (ΔR^2=+0.034; P<0.001) and were able to profile differences across IR levels within various MDCs (Kruskal-Wallis Test P<0.001). Brunner-Munzel Test showed Statistical differences (P<0.001) between neurological patients admitted to IR and HSR, as assessed by RCS-E and BI, respectively. Sensitivity analyses — stratified by age (≥75), LoS (> median), and outlier status (±1.5 IQR) confirmed the robustness of the main results across subgroups and conditions.
CONCLUSIONS: Findings support the combined use of RCS-E v13 and BI for patient profiling at admission, with CIRS showing comparatively lower effectiveness in this context.
CLINICAL REHABILITATION IMPACT: This study contributes to defining rehabilitation complexity in the Italian context. RCS-E v13 and BI emerged as complementary, objective tools for profiling care needs across MDCs and settings, with potential use for admission appropriateness, prognostic stratification, and care planning. Findings highlight that rehabilitation complexity requires a multifactorial assessment, not fully captured by comorbidity alone.

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KEY WORDS: Rehabilitation; Italy; Disability evaluation; Comorbidity; Needs assessment.

Rehabilitation is a path oriented to ensure that the person with a disability has the opportunity to achieve the best possible level of autonomy on the physical, functional, cognitive and psycho-social levels in order to guarantee the maximum possible participation in all activities of daily life within the limits of their own disability.[1]

As clearly stated in the European White Book on Physical and Rehabilitation Medicine (PRM)[2] the first step to achieve this goal is the definition of patients' needs. According to the 2011 Italian National Plan for Rehabilitation (INPR),[3] as still supported today in the new Italian Ministerial Decree on the criteria for appropriate rehabilitation admissions,[4] the appropriate evaluation of patients' needs should consider three clinical dimensions: disability, comorbidity and clinical complexity. However, the documents do not explain how these dimensions interact with each other and instead suggest that the definition of appropriate pathways of care based on patients' needs requires specific research. Instruments such as the Barthel Index (BI)[5] and the Cumulative Illness Rating Scale (CIRS)[6] are widely used to assess disability and comorbidity, respectively whereas clinical complexity still represents a new dimension to rate. In order to fill this gap, following the Evidence Based Medicine (EBM) recommendations, the Rehabilitation Complexity Scale (RCS-E v13) was introduced in Italy and validated in its Italian version through a prospective study involving eight intensive rehabilitation facilities in the Emilia-Romagna Region.[7, 8]

This scale was originally proposed in England in 2007[9] and validated in 2010[10] to determine rehabilitation complexity of patients' case-mix in neurological rehabilitation facilities and the related costs. Its use has progressively spread over time, as evidenced by the literature.[11-13] Initially, it included 4 domains: care, nursing, type and intensity (*i.e.* time) of rehabilitation treatments and medical needs. It underwent subsequent revisions based on clinical experience, until the latest "extended" version.[14] This last revision introduces patient's behavioral aspects in the "risk" subdomain and increments total score to 0-22 points.

The scale categorizes patients in terms of rehabilitation needs and considers the evidence for the cost-effectiveness of rehabilitation according to the English model. Data from RCS-Ev13, together with other outcome measures such as BI, inform the UK Rehabilitation Outcome Collaborative (UKROC),[15] a national neuro-rehabilitation database providing periodical reports about rehabilitation requirements, outcomes and cost-effectiveness.

Over time, international clinical and scientific interest in the instrumental assessment considering different aspects of rehabilitative patients, such us clinical complexity, has grown, leading to several cross-cultural validation studies,[16, 17] addition to Italian ones.[7, 8]

In the aforementioned project about RCS-E v13 introduction in Italy, this scale was applied also to patients belonging to different Major Diagnostic Categories (MDCs) like cardiological (MDC 05) and orthopedic rehabilitation (MDC 08), areas where its validity has already been psychometrically proved[7, 8] thus supporting the possibility of a wider use of the originally "neurological" scale.[14]

The organization of Italian rehabilitation reality is taken into account by differentiating facilities according to levels of care: Extensive Rehabilitation (ER), Intensive Rehabilitation (IR) and Highly Intensive Specialized Rehabilitation (HSR). Furthermore, the most representative of the Italian rehabilitative inpatient population (85%) includes four Ministry of Health categories: the Diseases and disorders of: the nervous system (MDC 01), the respiratory system (MDC 04), the cardiological system (MDC 05) and the musculoskeletal system and connective tissue (MDC 08).

This study, in line with previous work on the appropriateness of rehabilitation admissions,[18-20] aims to evaluate the contribution of the Italian RCS-Ev13, together with the BI and CIRS scales,[5, 6] in profiling the rehabilitative needs of patients belonging to the main four MDCs and admitted to the different levels of rehabilitation facilities on a national perspective, expanding the previous regional survey.[18] This represents the first large Italian application of an objective evaluation model for the description of different patients' profiles and pathways of care.

Materials and methods

This study was conducted in accordance with the revised version of the Helsinki Declaration and approved by the Bioethics Committee (CE) of the University of Milan

(All.4-Verb06.05.2015-PN22/15) and the Ethics Committees of all the facilities involved in the study.

Design

This is a multicentric observational cross-sectional study not influencing the patients' outcome but intended to objectively measure their characteristics without attempting to manipulate or influence the variables of interest. All patients provided written informed consent to participate in the study.

Setting and population

The study involved 27 Rehabilitation facilities, both public and private accredited hospitals, in 8 different Italian regions: Abruzzo, Emilia Romagna, Lombardy, Friuli-Venezia Giulia, Piedmont, Sardinia, Umbria and Veneto (Table I). Facilities voluntarity joined the study. Those in Emilia Romagna were different from the ones involved in the previous project studies.[7, 8, 18]

Methods

To conduct the multicentric research, a previous training phase was carried out at all participating centers. Each of them received:

- a video tutorial describing the study materials and procedures for installing and using the electronic case report (eCRF). The eCRF respected the Good Clinical Practice guidelines, including simplicity (clear design, ease of use), security (access control, data encryption) and reliability (data backups, seamless service);
- a video tutorial illustrating the rationale for the study, the presentation of the scales: RCS-E v13 (evaluation of clinical complexity), BI (disability assessment) and CIRS (assessment of comorbidity), plus some clinical cases as examples. Each score assigned to the example cases was explained;
- manuals for the RCS-E v13, BI scales, and CIRS;
- a series of practice cases to be completed and returned to the coordinating center.

Data collection began after verification of inter-rater scoring consistency across repeated training exercises using the Friedman Test — based on the Chi-square (χ^2) statistic — a non-parametric alternative to repeated measures ANOVA, appropriate for ordinal data and non-normally distributed samples. Based on earlier research,[7, 8, 18] all consecutively admitted patients underwent a standardized set of assessments commensurate with the requirements of the project.

TABLE I.—*Rehabilitation facilities included in the current study.*

Italian region	Hospital facility	Ownership
Abruzzo	ASL Pescara, Osp. di Popoli, UOC Medicina Fisica e Riabilitativa	PU
Emilia-Romagna	AOU Policlinico Sant'Orsola Malpighi (BO)	PU
	AOU di Parma, SC Medicina Riabilitativa	PU
	AUSL di Modena, Osp. di Baggiovara (MO)	PU
	AUSL Piacenza, Osp. Castel San Giovanni, Medicina Riabilitativa Intensiva	PU
	AUSL Piacenza, Presidio Ospedaliero val Tidone, Medicina Riabilitativa Intensiva	PU
	Clinica Cardinal Ferrari, Fontanellato (PR)	PR
Friuli Venezia Giulia	AOU Ospedali Riuniti di Trieste	PU
	Casa di Cura "Pineta del Carso", Duino Aurisina (TS)	PR
	Osp.Gervasutta di Udine, Istituto di Medicina Fisica e Riabilitazione	PU
Lombardia	AO S.Gerardo di Monza, Divisione di Medicina Fisica e Riabilitazione (MB)	PU
	Clinica Zucchi, Carate Brianza (MB)	PR
	Fondazione Don Gnocchi, Centro E. Spalenza di Rovato (BS)	PR
	Fondazione Salvatore Maugeri di Lumezzane (BS)	PR
	IRCCS Humanitas Research Hospital, Unità Operativa di Riabilitazione Ortopedica (MI)	PR
	IRCCS Humanitas Research Hospital, Unità Operativa: Riabilitazione Neurologica (MI)	PR
	Osp. Gaetano Pini di Milano	PU
	Osp. di Circolo e Fondazione Macchi di Varese, UOC Medicina Riabilitativa	PR
Piemonte	AO SS. Antonio e Biagio di Alessandria, Dipartimento Riabilitativo Borsalino	PU
	ASL CN 1, Struttura Complessa di Neuroriabilitazione (CN)	PU
	AOU San Luigi Gonzaga, Orbassano (TO)	PR
	Presidio Sanitario San Camillo di Torino	PR
Sardegna	AO G. Brotzu di Cagliari	PU
	ASL di Oristano, UOC di Neuroriabilitaizone	PU
Umbria	USL Umbria 1, Centro Ospedaliero Riabilitazione Intensiva, Passignano sul Trasimeno (PG)	PU
Veneto	Azienda Ulss 9, Osp. di Treviso, Degenza di Medicina Riabilitativa, Unità Gravi Cerebrolesioni e Mielolesioni	PU
	Osp. Riabilitativo di Alta Specializzazione, Motta di Livenza (TV)	PU

The list of facilities includes both public (PU) and accredited private (PR) healthcare institutions.

Data concerned the following variables: RCS-E v13, BI and CIRS scale scores, patient characteristics (*e.g.*, age, gender, admission date, level of care service admission, MDC, length of stay etc.). The adopted BI was the validated Italian version,[5] with a total score of 0-100. The CIRS rates the degree of pathology and impairment in 14 items, each one representing possible organs affected, including a psychiatric/behavioral category.[6] It contains multiple scores: total score (CT), Severity Index (SI) as average of the first 13 categories scores and Comorbidity Index (CI) that is the number of items ranking greater than three in disease severity score.

Physicians treating the patient had to administer the scales within 72 hours from admission and to collect the scales scores together with the other required data on eCRF and periodically send them to the data manager. On eCRF each patient was recorded using a unique identification code as well as each rehabilitation service.

All patients were enrolled in consecutive admission order to avoid selection bias and to achieve a representative cross-section of the population.

To reduce the systematic or random bias of measurement errors (misclassification or missing data) related to fundamental data (*e.g.* age, gender, date of hospitalization, date of transfer to rehabilitation, date of hospital discharge, etc.), the eCRF were structured to include the ex-ante controls. Missing data were treated following Listwise deletion procedure.[21] Finally, a multilevel statistical analysis adjusted on age, gender and Length of Stay (LoS) was chosen to avoid confounding effects.

Sample size calculation

Considering the RCS-E v13 (an ordinal scale) as the primary variable of interest, the sample size was estimated following the method described by Turner-Stokes *et al.*[9] (cut-off = 9; Se=88%, SP=89%), assuming a 50% prevalence of patients with complex rehabilitation needs requiring appropriate care settings. Based on these parameters — and using sensitivity, specificity, and cut-off values validated for the Italian version of the scale[18] — the calculation was conducted with reference to the most frequent MDC code (MDC 08). Assuming a 95% confidence level, a desired precision of 2%, and a 6% dropout rate, and using the Chi-square test as the reference statistical procedure, the required sample size for MDC 08 was estimated accordingly. This estimate was then extrapolated to the four selected MDCs across the involved IRs. Finally, after incorporating estimated needs related to HSR and ER levels of rehabilitation service, the overall required project sample size was determined to be 2292 patients.

Statistical analysis

The study population was divided into three subgroups according to level of care admission: IR, ER, and HSR. Comparisons were made among the groups with epidemiological descriptive analysis. Variables were reported as frequencies and percentages, mean, standard deviation (SD), median and interquartile range (IQR).

Spearman partial correlation coefficient (ρ) with 95% confidence intervals, corrected for age and LoS, was performed to measure the strength of association among the three scales. The strength of correlation was interpreted according to the guidelines suggested by Evans: 0.00-0.19 very weak, 0.20-0.39 weak, 0.40-0.59 moderate, 0.60-0.79 strong, 0.80-1.0 very strong.[22]

To further investigate and better understand the underlying dimensions explaining the intercorrelations among the three measurement scales we also conducted an Exploratory Factor Analysis (EFA). The possible relation between the clinical-scales profiles at admission and LoS as has been investigated with a multivariate linear regression. The Kruskal-Walli's Test, with subsequent contrasts conducted using the Dwass-Steel-Critchlow-Fligner method, was used to further investigate differences between the MDCs of the IR level. The Brunner-Munzel Test[23] was applied to examine differences in MDC01 between IR and HSR levels. We conducted sensitivity analyses by replicating key tests (correlation, group comparisons, regression) in clinically relevant subgroups (*e.g.*, age ≥75, LoS > median). Statistical analyses were performed using Jamovi version 1.1.9 (Jamovi, Stat.Open.Now). Significant level was set at $P<0.05$.

Data can be provided upon request.

Results

The total number of consecutively admitted patient was 2809: 1445 female (51.9%) and 1338 male (47.6%), gender data were missing for 26 subjects, mean age 70.1±14.8 years. The mean LoS were 91.7±66.2 days for HSR, 71.0±73.4 for ER and 37.8±35.5 for IR levels (MDC 01: 51.0±40.4; MDC 04: 27.2±19.5; MDC 05: 20.8±8.7; MDC 08: 25.9±28.0). On the total sample, missing data for key variables (age, LoS, gender, psychometric scales) accounted for 2.10%, well below the 5% bias threshold and therefore considered negligible. Enrollment was conducted across 15 months. Each subject was assigned to a unique primary MDC, without any multiple classifications.

Patients representing less frequent pathologies than the main four MDCs were grouped into a single class named

"Other rehabilitation problems" (N.=34, 1.2%). These data were not included in the main analysis. Data from ER setting were also excluded from statistical analysis due to small sample size. Descriptive statistics of the ER sample are presented in Table II. Table III reports descriptive statistics for the total IR and HSR sample.

Strong Spearman's correlations emerged, with Age and LoS as control variables, between RCS-E v13 and BI (ρ=-0.61). Weak correlations were observed between all CIRS indices and the RCS-E v13 and BI scales, respectively: CIRS_ToT (ρ=0.36 and 0.32), SI (ρ=0.35 and 0.29), CI (ρ=0.30 and 0.27), despite being statistically significant (P<0.001). Sensitivity analysis results are available in Supplementary Digital Material 1 (Supplementary Table I and II). Exploratory factor analysis (EFA) was conducted employing the minimum residual extraction method with oblique (oblimin) rotation. The analysis supported a two-factor solution, accounting for 85% of the total variance, with acceptable sampling adequacy (Kaiser-Meyer-Olkin measure = 0.747) and a statistically significant Bartlett's test of sphericity ($\chi^2_{(10)}$=17.691, P<0.001). Factor 1 was predominantly defined by CIRS indices (SI and CI) and re-demonstrated only a weak significant correlation with LoS (Spearman's ρ=0.219, P<0.001). Factor 2, comprised of RCS-E and BI scores, exhibited a strong and highly significant association with LoS (Spearman's ρ=0.677, P<0.001). The moderate correlation observed between the two factors (ρ=0.443, P<0.001) confirmed that they represent related yet distinct constructs. Given the presence of these two distinct factors and the confirmed weak relationship between Factor 1 and LoS in subsequent regression analyses, further investigation was directed toward the individual scales loading on Factor 2. These scales demonstrated a more direct and robust association with LoS, thereby justifying their exclusive consideration in further analyses.

A multiple linear regression analysis was conducted to examine the relationship between the RCS and BI total scores and the LoS. The initial model including only the main effects of RCS and BI accounted for 24% of the variance in LoS (R^2=0.24), with both predictors reaching statistical significance (P<0.001). The addition of the RCS × BI interaction term significantly improved model fit, as indicated by an increase in R^2 (from 0.24 to 0.274), decreased AIC (from 28,220 to 28,095) and BIC (from 28,244 to 28,125), and a lower RMSE (from 38.5 to 37.7). The interaction effect was highly significant (P<0.001), suggesting that the combined effect of the two scales provides a more accurate prediction of LoS than either scale alone. Similar patterns for the RCS × BI interaction were observed in the sensitivity analyses (Supplementary Digital Material 2: Supplementary Table III, IV, V, VI).

Significant differences in clinical complexity and disability profile across IR levels within various MDCs were ob-

TABLE II.—*Descriptive characteristics of the sample in the extensive care level (ER)*

MDCs	Age	LoS	RCS_TOT	BI_TOT	CIRS_TOT	CIRS_SI	CIRS_CI
MDC 01							
N	16	16	14	16	16	16	16
Missing	0	0	2	0	0	0	0
Mean	74.10	78.30	10.90	12.80	21.10	1.45	6.63
Median	77	43	12	5	23	2	7
SD	17.60	75.80	2.43	19.30	7.61	0.54	2.16
IQR	11	114	3	21	12	1	3
MDC 08							
N	1	1	1	1	1	1	1
Missing	0	0	0	0	0	0	0
Mean	81.00	12.00	9.00	30.00	22.00	1.69	8.00
Median	81	12	9	30	22	2	8
SD	NaN	NaN	NaN	NaN	NaN	NaN	NaN
IQR	0	0	0	0	0	0	0
Other rehab problem							
N	5	5	5	5	5	5	5
Missing	0	0	0	0	0	0	0
Mean	76.40	59.60	11.80	3.00	28.20	2.09	9.40
Median	80	34	13	0	27	2	8
SD	15.40	74.00	2.59	4.47	7.46	0.61	2.51
IQR	11	14	5	5	7	1	3

Ministry of Health categories: the Diseases and Disorders of Nervous System (MDC 01), and the Musculoskeletal System & Connective Tissue (MDC 08).
SD: standard deviation; IQR: interquartile range.

TABLE III.—*Descriptive statistics of the project sample by IR and HSR levels of care.*

IR level of care	Age	LoS	RCS_TOT	BI_TOT	CIRS_TOT	CIRS_SI	CIRS_CI
MDC 01							
N	1184	1184	1179	1183	1184	1182	1182
Missing	0	0	5	1	0	2	2
Mean	70.14	51.06	10.56	28.73	15.99	1.15	5.19
Median	74	43	10	20	15	1.08	5
SD	14.84	40.37	1.97	25.41	5.98	0.43	2.13
IQR	19	31	3	45	8	1	3
MDC 08							
N	828	828	812	827	828	828	828
Missing	0	0	16	1	0	0	0
Mean	73.88	25.89	9.01	50.31	12.35	0.89	4.28
Median	76	23	9	50	12	0.85	4
SD	12.26	27.99	1.42	19.73	6.11	0.43	2.26
IQR	14	14	2	30	8	1	3
MDC 04							
N	198	198	198	198	198	198	198
Missing	0	0	0	0	0	0	0
Mean	72.146	27.192	9.116	62.727	14.652	1.084	5.071
Median	73	24	9	70	14	1.08	5
SD	10.36	19.45	2.053	29.439	6.198	0.454	2.405
IQR	13	13	2	45	10	1	4
MDC 05							
N	221	221	219	221	221	221	221
Missing	0	0	2	0	0	0	0
Mean	73.89	20.81	7.55	69.21	17.21	1.29	6.18
Median	76	21	7	75	17	1	6
SD	9.80	8.71	1.42	24.75	5.20	0.38	1.86
IQR	12	8	1	25	6	0	2
Other rehab problem							
N	23	21	23	23	23	23	23
Missing	0	2	0	0	0	0	0
Mean	69.83	41.78	10.35	43.91	20.78	1.51	6.65
Median	72	31	11	45	19	1	6
SD	14.57	29.98	1.77	22.41	7.95	0.55	2.90
IQR	21	23	2	30	15	1	5
HSR level of care							
N	333	333	333	333	333	332	332
Missing	0	0	0	0	0	1	1
Mean	56.78	91.74	13.18	10.80	19.88	1.44	6.49
Median	60	72	13	0	20	1	7
SD	17.79	66.24	2.35	18.86	6.39	0.45	2.09
IQR	23	84	2	15	9	1	3

Ministry of Health categories: the Diseases & Disorders of Nervous System (MDC 01), the Respiratory System (MDC 04), the Cardiological System (MDC 05) and the Musculoskeletal System & Connective Tissue (MDC 08); levels of care: Intensive Rehabilitation (IR) and Highly Intensive Specialized Rehabilitation (HSR). SD: standard deviation; IQR: interquartile range.

served through the Kruskal-Wallis Test (RCS-E: $\chi^2_{(3)}$=623, P<0.001, ε^2=0.259; BI: $\chi^2_{(3)}$=636, P<0.001, ε^2=0.262), with medium-to-large effect sizes. Pairwise comparisons using the Dwass-Steel-Critchlow-Fligner Test revealed several significant differences across MDC groups for both RCS-E and BI scores. For RCS-E, all pairwise comparisons were statistically significant (P<0.001), except for the comparison between MDC 08 and MDC 04 (W=1.74, P=0.606), indicating similar complexity scores between these two groups. In contrast, BI scores differed significantly in all comparisons (P<0.001), except between MDC 04 and MDC 05 (W=-2.62, P=0.248), suggesting that functional independence levels were comparable in these two groups. Sensitivity analysis results for these findings are reported in Supplementary Digital Material 3 (Supplementary Table VII, VIII). In MDC 01, the total scores of the scales can effectively describe different patient profiles admitted to IR and HSP. The Brunner-Munzel Test revealed significant differences in RCS and BI scores between HRS and IR patients. The probability that a randomly selected HRS

patient had a lower RCS score than a randomly selected IR patient was 0.182 (95% CI: 0.154-0.211; BM statistic = -22.1, df=453, P<0.001), indicating greater clinical complexity in the HRS group. Conversely, the probability that a patient from the HRS group had a higher BI score than one from the IR group was 0.748 (95% CI: 0.718-0.778; BM statistic = 16.3, df=498, P<0.001), reflecting significantly greater functional independence in the IR group. Sensitivity analysis of these results is reported in Supplementary Digital Material 4 (Supplementary Table IX, X). The statistical comparison of MDC 01 between IR and HRS levels, considering the RCS-E v13 domains and the BI items, revealed statistically significant differences (Chi-square test of goodness of fit, P<0.001) across all parameters, as shown in Figure 1 and Figure 2, respectively.

Discussion

To evaluate the contribution of the integration of the RCS-E v13 with the Barthel Index and the Cumulative Illness Rating Scale in profiling rehabilitative patients at admission, this research, explored a large sample of consecutive-

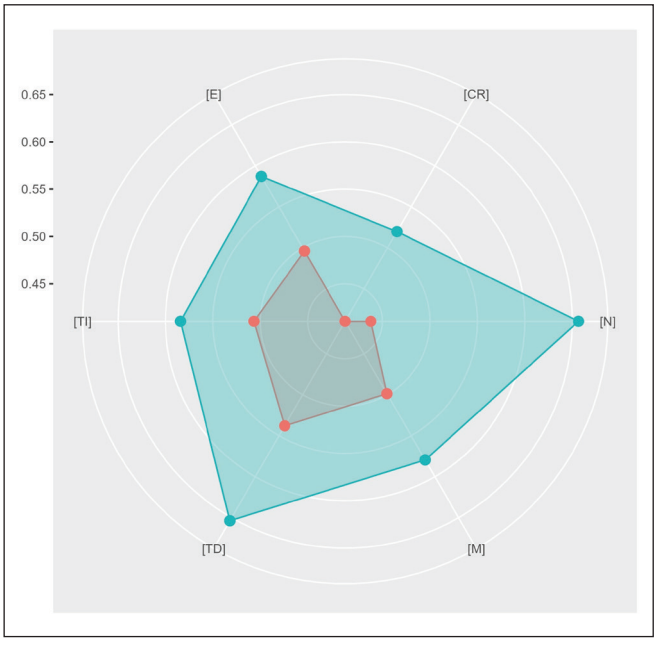

Figure 1.—Graphical comparison of RCS-E v13 domains in HSR and IR neurological rehabilitative patients. Rehabilitation Complexity Scale score domains are shown in red for Intensive Rehabilitation (IR) patients and in blue for Highly Specialized Post-Acute Rehabilitation (HSR) patients.
CR: basic care and support needs; N: nursing needs; M: medical needs; TD: therapy needs - number of disciplines; TI: therapy needs - intensity; E: equipment.

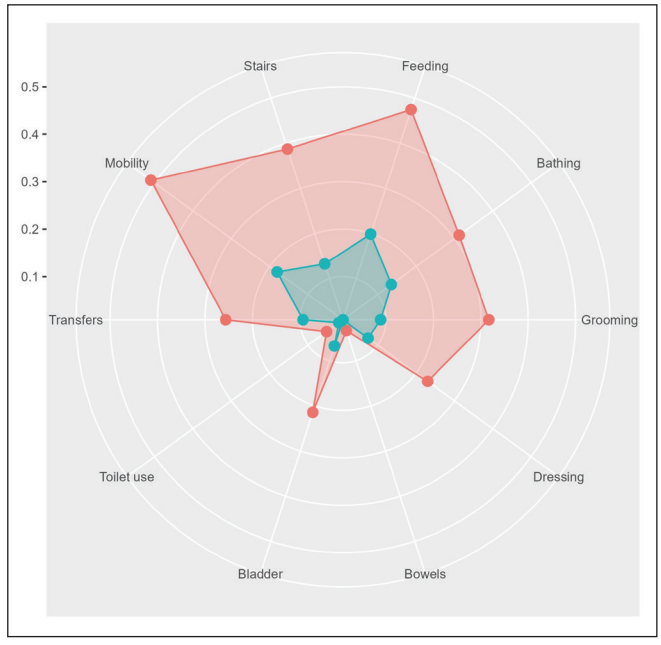

Figure 2.—Graphical comparison of BI Items in HSR and IR neurological rehabilitative patients. Barthel Index items are shown in red for intensive rehabilitation (IR) patients and in blue for highly specialized post-acute rehabilitation (HSR) patients.

ly admitted patients (N 2809). The sample was collected from 25 rehabilitation facilities — public and accredited private centers — across eight Italian regions and encompassing different levels of care (IR, ER, and HRS) and the main rehabilitative MDCs, ensuring sufficient heterogeneity to support the generalizability of the findings.

Strong negative correlations were observed between RCS-E and BI scores, supporting their complementary nature in assessing patient profiles, whereas weaker correlation emerged between these functional measures and comorbidity indices (CIRS). Exploratory factor analysis further confirmed the presence of two distinct yet related factors: one reflecting comorbidity burden (CIRS-based) and the other capturing the functional and clinical status (RCS-E and BI), with the latter showing a stronger association with length of stay (LoS). These results are not surprising, as they are consistent with the previous study conducted in the Emilia Romagna Region,[8, 18] as well as with the study by Galletti *et al.*[24] and also align with more recent evidences in the filed.[25] The Italian network study on the RCS-E for respiratory patients[24] showed that the CIRS score does not directly reflect patients' rehabilitative needs, supporting the hypothesis that comorbidities per se, are not necessarily associated with clinical complexity or disability. This interpretation is further supported by Kab-

boord *et al.*[25] emphasized that the relationship between comorbidity and functional outcomes remains modest and uncertain, with no gold-standard comorbidity tool available for prognostic use in rehabilitation.

The RCS and BI, instead, appear to more effectively identify rehabilitation patient profiles by capturing key care needs related to physical and/or cognitive autonomy, medical and therapeutic demands, and the level of nursing or personal assistance required. Their utility as comprehensive and tailored assessment tools — aligned with patient clinical severity and MDC — is supported by group comparison results. Specifically, analyses across MDCs revealed significant differences in RCS-E and BI scores, particularly between IR and HRS levels within MDC 01. Patients in HRS showed greater clinical complexity and lower autonomy than those in IR, confirming the sensitivity of both tools in profiling patient characteristics. Furthermore, within the IR level, the two scales detected significant differences across MDCs, confirming — on a national level — the results previously obtained in a study conducted in the Emilia-Romagna region,[8, 18] and extending their applicability to patients with respiratory conditions (MDC 04). These data are also supported by Vitacca *et al.*,[12] who showed that RCS-E scores, when combined with the BI and other scales, can provide useful information on the care burden during in-hospital pulmonary rehabilitation.

Notably, both scales (BI and RCS-E) also proved to be significant predictors of length of stay (LoS), as shown by our regression analyses, with their combined use offering a more robust model of LoS determinants than either scale alone. These findings further strengthen the value of RCS and BI as complementary tools for individualized rehabilitation planning based on an objective patient profile.

The results of our study suggest that integrating the RCS-E in the assessment of rehab patients through a stratified and individualized approach could support more accurate intervention planning and resource allocation, potentially leading to improved functional outcomes. Although these findings are representative of the Italian clinical governance model, they align with international evidence where RCS scores, combined with other scales, are used to allocate patients to the most appropriate intensity of care.[26-29]

Limitations of the study

However, some limitations of the present study should be acknowledged. First, the assessment tools (RCS-E and BI) were administered only at admission, providing no information on their ability to monitor changes in care needs throughout the inpatient rehabilitation pathway. Second, the limited number of eCRFs collected from ER setting led to their exclusion from comparative analyses, reducing the scope for evaluating differences across all care intensities. This is particularly relevant given the growing importance of ER in the national rehabilitation system, especially following the recent Ministerial Decree 5/2024[4] and the introduction of the new Hospital Discharge Form (SDO-r).[30] Additionally, the weak associations between the scales, CIRS, and LoS — consistent with previous studies[8, 14, 18] remain an important consideration. Clinical practice and evidence indicate that comorbidity has a meaningful impact on intervention planning and rehabilitation trajectories. As emphasized by both clinical practice and the scientific literature,[29, 30] comorbidity plays a crucial role in the real-world profiles of rehabilitation patients. Nonetheless, controversies persist regarding the quantitative assessment of this variable.[25] The core of the debate lies not in the relevance of comorbidity itself, but in how it should be assessed and which comorbid conditions most significantly influence specific rehabilitation outcomes.

Nevertheless, this study demonstrates several important strengths. First, to ensure the robustness of our findings, we performed a series of sensitivity analyses. These analyses involved re-running the primary tests — correlations, group comparisons, and regressions — on stratified subgroups, including older patients (age ≥75 years) and those with length of stay (LoS) above the median. The results remained consistent across all sensitivity analyses, supporting the stability, validity, and generalizability of the main findings. In particular, the sensitivity analyses confirmed the primary patterns of correlation between RCS-E and BI, while consistently showing weak correlations between CIRS and both scales as well as with LoS. Moreover, they replicated the results of group comparisons across MDC categories and levels of care. These convergent findings, detailed in Supplementary Digital Materials 1, 2, 3, and 4, strengthen confidence in the reliability of our results across different patient subgroups and analytic conditions.

The results confirmed the feasibility and clinical utility of integrating RCS-E and BI as valid, objective, and complementary tools to profile patients and to define their clinical and functional characteristics at admission across different care intensities and MDCs. Their joint use could allow for stratified and individualized assessment of care burden, informing resource allocation and supporting clinical decision-making, with direct implications for the implementation of appropriateness criteria introduced by the Ministerial Decree 5/2021.[4] Furthermore, the objective

profiling enabled by these tools could support multidisciplinary collaboration by providing a shared framework for clinical teams to plan and coordinate interventions. Although this study focused on admission assessments, the tools hold potential for longitudinal monitoring of patient progress throughout the rehabilitation process. Importantly, the quantitative data derived from RCS-E and BI could inform healthcare policy and strategic planning, aiding in the efficient allocation of rehabilitation resources. Although rehabilitation settings vary nationally, the consistency of findings observed across a large multicenter sample reinforces the external validity of the results and supports their wider applicability in routine clinical practice

Conclusions

This study confirms that the integrated use of RCS-E and BI represents a valid and objective set of complementary tools for profiling care complexity in rehabilitation. Their combined application suggests usefulness in supporting prognostic stratification and care planning, with direct implications for the implementation of the appropriateness criteria outlined in DM 5/2024. In contrast, comorbidity alone does not adequately capture rehabilitation needs, underscoring the value of a multidimensional assessment approach. Future studies will further explore the application of these complementary tools as suitable instruments to investigate the efficacy of rehabilitation efforts.

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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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Authors' contributions
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Supplementary data
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