The Journal of Frailty & Aging 15 (2026) 100158

Contents lists available at ScienceDirect

The Journal of Frailty & Aging

journal homepage: www.elsevier.com/locate/tjfa

Original Research

A new simplified minimum data set better predicts outcomes for individuals admitted to intermediate care functional recovery units in catalonia

M Inzitari [a,b,c,*], E Vela [d], C Martín Pardina [d], E Vallés [d], L Viale [d], G Valls [a,e], M.A Gil [f], M Llonch [a,g], K Covinsky [h], J Deardorff [h]

[a] Operative direction for the transformation of intermediate care, Department of Health, Government of Catalonia, Spain
[b] REFiT aging research group, Parc Sanitari Pere Virgili and Vall d'Hebron Institute of Research (VHIR), Barcelona, Spain
[c] Faculty of Health Sciences, Universitat Oberta de Catalunya (UOC), Barcelona, Spain
[d] Division of information systems, Catalan Health Service, Department of Health of Catalonia, Spain
[e] Division of healthcare, Catalan Health Service, Department of Health of Catalonia, Spain
[f] Santa Creu de Jesús Intermediate Care Hospital, Tortosa, Spain
[g] Consorci Sanitari de Terrassa, Terrassa, Spain
[h] Division of Geriatrics, University of California, San Francisco, USA

ARTICLE INFO

Keywords:
Aging
Intermediate care
Geriatric rehabilitation
Case-mix
Length of stay
Home discharge

ABSTRACT

Background Intermediate care functional recovery (ICFR) units in Catalonia, Spain, provide post acute care and geriatric rehabilitation. Providers report a Minimum Data Set (MDS), initially developed to classify patients into resource utilization groups (RUG), to adjust public reimbursement. The MDS, completed by health professionals, is time consuming and diverges from routine clinical assessment. Objectives We developed new intermediate care case-mix indexes (ICMI), based on admission diagnosis and function, and tested whether ICMIs better predict length of stay (LOS) and discharge destination, compared to RUG. Methods We developed the ICMIs using 122,754 ICFRs admissions (years 2017–18–19–22): we categorized individuals by diagnosis and four levels of activities of daily living (ADL). To obtain ICMIs, each category was assigned a weight based on associations with ICFR LOS and "unsuccessful discharge" (death or other service versus home). Then, in the 2023 cohort, we compared the performance of four models (base model (age, sex, income), base+RUG, base+ADL, base+ICMIs) to predict LOS >57 days and unsuccessful discharge. Results The 2023 cohort included 31,640 patients (median age [IQR]=82.0 [75.0;88.0], 57% women). When predicting dichotomous LOS, the area under the ROC curve (AUC) increased from 0.56 [95% CI=0.544–0.57] to 0.56 [95% CI=0.55–0.56] (base+RUG), 0.59 [95% CI=0.58–0.61] (base+ADL), and 0.63 [95% CI=0.62–0.65] (base+ICMI). AUC to predict discharge destination showed similar improvements (0.55 [95% CI=0.54 0.55], 0.59 [95% CI=0.58–0.59], 0.64 [95% CI=0.63–0.64], 0.66 [95% CI=0.65–0.66], respectively). Conclusions In Catalan ICFRs, new, simplified, case-mix indicators improved prediction of LOS and discharge destination, compared to existing tools. This study can inform new policies for intermediate care, adding a validated instrument to improve evaluation and reimbursing systems.

1. Introduction

Older adults frequently experience multiple concurrent health and social issues and undergo frequent care transitions [1]. In many Western countries, short-term services at the interface between acute care and home settings aim to ensure continuity of care, promote recovery, and restore independence and confidence following acute health crises. These services are included under the umbrella of "intermediate care" [2]. In the USA, this type of care is often provided in Skilled Nursing Facilities. In 1986, Catalonia, a region of Spain with a large aging population and universal free healthcare, established an extensive intermediate care network that now includes 96 facilities and more than 8000 beds [3]. The network is mainly oriented to promote early discharge from conventional hospitals and admission avoidance through direct referral from primary care, providing post-acute geriatric rehabilitation and recovery, in the so-called "convalescence" or intermediate

* Corresponding author at: Department of Health, Government of Catalonia, Pavelló Ave Maria, Travessera de les Corts, 131-159, 08028 Barcelona, Catalonia, Spain.

E-mail address: minzitari@perevirgili.cat (M. Inzitari).

https://doi.org/10.1016/j.tjfa.2026.100158
Received 15 June 2025; Received in revised form 16 March 2026; Accepted 17 March 2026
Available online 10 May 2026
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care functional recovery (ICFR) units, as well as palliative and dementia care.

Like many Western countries, Catalonia is undergoing various demographic changes associated with aging of the population, including an increase in multi-morbidity and advancements in treatments for prevalent diseases, such as cancer or stroke [4]. These changes, coupled with mounting pressure on the healthcare system, lead to progressively shorter hospital stays and higher demand for intermediate care [5–7]. As a result, Catalonia's intermediate care network is undergoing transformation, aimed at providing more patient-centered, proactive, efficient, and equitable care, closer to individuals' places of residence.

Data play a critical role in informing policy-making, care planning, and resource allocation. In Catalonia's ICFR, a comprehensive system-wide data reporting has been in place since its inception, primarily based on the Minimum Data Set (MDS), a tool developed under the Omnibus Budget Reconciliation Act of 1987 (OBRA '87) in the USA [8]. This tool is currently used by the public health administration to adjust reimbursements. The MDS facilitates the assessment of case complexity through the Resource Utilization Group (RUG) [9], a weighted classification system based on the costs associated with care provision. However, several reasons make this system outdated. First, it imposes a significant registration burden on healthcare professionals. Secondly, it is based on tools diverging from those routinely utilized in the Comprehensive Geriatric Assessment by staff in Catalonia, resulting in duplicative records. For example, the activities of daily living (ADL) scale of the MDS [10]. is more relevant for the nursing home setting, and healthcare professionals in Catalonia more routinely use the Barthel index [11]). Third, the RUG classification [9]. is still based on the original cost structure of US nursing homes and has never been contextualized nor updated to a new geographic setting such as Catalonia. Fourth, mandatory serial follow-ups every 21 days are not useful when the length of stay (LOS) in post-acute units slightly exceeds one month. Finally, in Catalonia, RUG is linked to a variable portion of reimbursement, contingent upon the complexity of case-mix whereby providers are ranked based on their mean RUG complexity for a certain year. This has led to a decline in the reliability of reported data, mirroring a similar trend observed in the US system of skilled nursing facilities [12].

Considering these challenges and the ongoing transformation of Catalonia's intermediate care system, there is a pressing need to transition towards a simpler data record, more aligned with routine clinical assessments. Evidence suggests that, in frail older patients, functional status could be the main driver of complexity [13]. however, most of these studies were performed in acute settings [14] .

The goal of this study was to develop a new, simplified case-mix indicator and to compare its performance with the more extensive MDS assessment. This study was structured in two phases. First, we used a comprehensive dataset to develop a simplified measure of case-mix, which we term intermediate care case-mix indexes (ICMI), based only on the primary ICFR admission diagnosis and functional status assessed by ADL dependencies. Then, we compared the performance of this simplified measure of case-mix against the RUG score when predicting length of stay and placement at discharge. This work is part of a broader strategic policy to replace the previous MDS with a simplified dataset.

2. Methods

Design of the study. Cohort study, using administrative system-wide data. The study report follows STROBE guidelines [15]. for cohort studies **(see Supplementary material for the STROBE checklist).**

Setting and population. The Catalan healthcare system is a public, free, universal coverage system including general hospitals, primary care, intermediate care (an umbrella of post-acute and sub-acute services) and mental health resources. Intermediate care has the goal to facilitate hospital discharge or prevent unnecessary admission to general hospital, and constitutes a large network including 96 centers with more than 8000 beds [3]. Interdisciplinary care is provided by physicians, nurses, physical and occupational therapists, social workers, clinical pharmacists, and other professionals. It is mainly oriented to maximize function in daily life. A centralized dataset is located at the healthcare administration of the regional government (Department of Health) and integrates different data of all the residents in the region (identification, address, insurance status, level of coverage, minimal standardized data reported by the providers at every contact with the healthcare system) which are linked through a unified identifier.

First, we used whole-system data from all admissions to in-bed ICFR units in Catalonia from 2017, 2018, 2019 and 2022 to build case-mix indicators. We excluded 2020 and 2021 to avoid the effects of the transitory adaptation of the healthcare system to the COVID-19 pandemic. Next, we tested these indicators in a similar cohort of individuals using admissions to intermediate post-acute services in 2023.

2.1. Independent variables

Variables were extracted from the available, mandatory MDS of Catalonia, and complemented with other administrative records (such as the central register of population and the register of co-payment for pharmaceutical prescriptions to assess income level).

Sociodemographic variables included age (categorized in 5 groups, <45, 45–64, 65–74, 75–84, >84 years), gender, and income. In Catalonia, all residents are assigned to an income group, linked to co-payment for medications, defined as: high income (>€100,000 / year), average (€18,000 - €100,000), low (<€18,000) and no income (or receiving social contribution)).

Intermediate care case-mix indexes (ICMIs). To calculate the new ICMIs, we included the following variables:

- *Primary ICFR admission diagnosis.* We grouped admission diagnoses based on a minor modification of the Clinical Classification Software (CCS) [16]. We assigned CCS categories with <50 cases to the most similar category (e.g. "CCS 00,004: Mycosis" was assigned to "CCS 00,008: Other infections") and grouped categories with little clinical significance as primary diagnoses (for example, 00,084: Headache, or 00,120: Haemorrhoids into "CCS 00,259: Residual codes"). Using this approach, categories were reduced from 262 to 182.
- *ADL function.* The available dataset included ADLs as recorded within the MDS, assessing capacity (across 6 values, from independent to needing complete support in the activity) in 9 activities: eating, dressing, personal care/hygiene, bathing, transfers (in and out of bed and/or chair), bowel control, bladder control, mobility in the room, mobility in the hallway. We based our measure of functional status on the Barthel Index as this is the most used functional scale in Catalonia and is being considered for implementation in a future dataset. The Barthel index ranges from 0–100 with 0 points indicating total disability and 100 points indicating complete autonomy. To align the ADL score derived from the MDS with the Barthel Index [11],we recalibrated the MDS-ADL tool on a scale of 0–100 points by assigning each activity a proportional score (for a full description of the conversion of MDS-ADL scale into a 100 points ADL scale, similar to the Barthel index, see **Supplementary material**). The rescaling procedure generated 72 missing episodes in the first wave and 6 missing episodes in the 2023 wave, which were excluded from the analysis. Scores on our modified Barthel index were categorized in 4 groups: complete (<20 points), high (20–39 points), moderate (40–59 points) and low or no disability (≥60 points).

RUG-III score [17]. RUG-III summary scores were obtained from the MDS, a comprehensive assessment of a patient's function (ADLs), clinical, cognitive, mood and behavioral status, communication, hearing and vision, continence, skin and nutritional status, medications, treatments and procedures, therapies and services. The RUG-III, still in use in

Catalonia, system classifies patients into one of 44 groups. These groups reflect the intensity of resource utilization and care needs. The final RUG-III scores are weighted based on the use of resources and influence reimbursement and care planning in long-term care settings. Higher scores indicate greater resource requirements. In our case, the minutes of physiotherapy were excluded from the calculation of the RUG-III as they are considered poorly reliable in Catalonia because they heavily influence patient complexity and therefore reimbursement. For a trained professional, the time to complete the MDS could take 60 min.

2.2. Other variables of the integrated care process

Previous use of healthcare resources. Information on previous hospitalizations was extracted from the general database of the Catalan Health Surveillance System (CHSS) [18].

Given that Catalonia is a healthcare system with universal coverage, data on previous healthcare utilization are very reliable. We included information on:

- The LOS in the acute episode before the admission in post-acute care (in days). In case of an admission directly from home or nursing home, the assigned value was 0.
- The number of days of acute hospitalization in the previous 6 months (in days).

2.3. Outcomes

We chose to predict ICFR LOS and unsuccessful ICFR discharge as these represent patient-centered outcomes and are associated with increased healthcare cost. Discharge destination was collected from the discharge MDS assessment, and length of stay was calculated based on admission and discharge dates on the discharge MDS assessment.

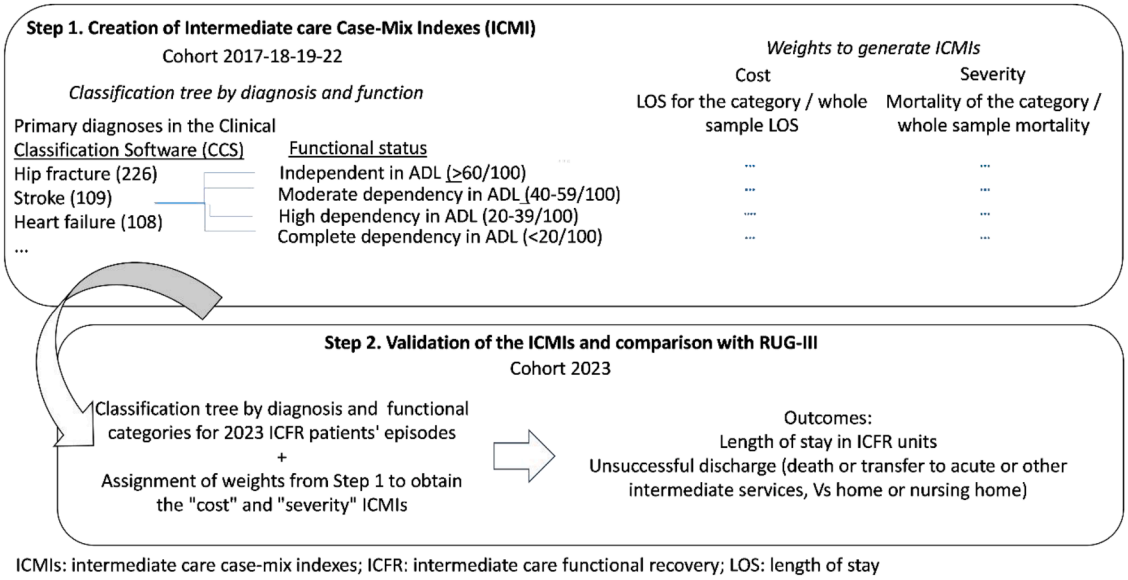
- Length of stay in the ICFR: we modelled LOS both as a continuous variable (log transformed) and a dichotomous variable (>57 days of stay versus ≤57 days, because 57 represents the median plus interquartile range, which corresponded to the 90% percentile)).
- Unsuccessful discharge from ICFR: we created a variable indicating a negative outcome (a composite of death, readmission to the acute hospital from ICFR and discharge to another intermediate care service, usually a longer-term stay unit) versus discharge at the final living destination (home or a nursing home). This represents a meaningful patient-centered outcome, given that one of the primary goals of intermediate care is for individuals to improve their health and functional abilities, enabling them to return to their prior residence without experiencing a hospital readmission or death [19].

2.4. Statistical analysis

Description of the sample was presented as N% or median [Interquartile Range or IQR], for both the 2017–22 cohort and the 2023 validation cohort.

Creation of the intermediate care case-mix indexes (ICMIs) (proxies for cost and severity case-mix indicators). We built two new case-mix indicators using data from years 2017–18–19–22. Fig. 1 displays the full steps to create the ICMIs. In brief, we first divided each modified CCS admission diagnostic code (182 total) into 4 groups by ADL function categories (as indicated above), which resulted in 721 categories (instead of the expected 728, because 7 categories did not include any patient). We subsequently assigned a "weight" to each category based on two indicators: i) trimmed average length of stay (LOS) (because the length of stay is not normally distributed and a few extreme values could distort results, cases above a certain cut-off were excluded (cut-off points were: 184 days for categories with fewer than 30 discharges (2017–2019, 2022) and the 95th percentile, or the third quartile plus twice the interquartile range for the other categories). and ii) average mortality rate. The "weight" given to each category for trimmed average LOS was calculated as the trimmed average LOS for that category divided by the trimmed LOS for the whole sample. The "weight" given to each category for average mortality was calculated as the average mortality rate for that category divided by average mortality rate of the whole sample. This approach follows the idea behind the All Patient Refined Diagnosis-Related Groups (APR-DRG) [20], in use for acute care, in which the indicator is weighted for either use of resources or mortality. We consider the ICMI weighted by LOS as a proxy for costs (as costs increase by any day of stay) and the ICMI weighted by mortality as a proxy for severity of the episode. The obtained ICMIs were then used in the validation cohort of 2023.

Validation of the ICMI in the 2023 cohort. We performed different regression analyses (linear regression for the continuous LOS outcome, logistic regression for the dichotomous LOS and discharge destination outcomes), building, for each outcome, four different models:



ICMIs: intermediate care case-mix indexes; ICFR: intermediate care functional recovery; LOS: length of stay

Fig. 1. Summary steps to build and validate the Intermediate care case-mix indexes.

- The "base model" included only age, gender, and income
- A second model including the "base model" + RUG score
- A third model including the "base model" + ADL score
- A fourth model including the "base model" + new ICMIs

Our primary goal was actually to compare the second and the fourth of the models above. As a secondary analysis, we explored if model performance improved with the addition of previous healthcare utilization (either days admitted to the acute hospital in the previous 6 months or LOS in the acute admission) to the final fourth model.

In each model, the basic variables (age, sex, income) were forced in. The explanatory capacity of each model was estimated with either R2 (log-linear regressions) or the area under the receiver operating characteristic curve (AUC) (for logistic regression).

To assess for any optimism in the models, a resampling model validation was performed using 1000 bootstrap samples in order to return bias-corrected indexes of the model [21].

Ethical considerations. The study used retrospective, anonymized data from the healthcare administration. No personal data were used, and all patient data were encrypted, so that no personal identification would be retrievable or traceable to the original source from the working database. The study complied with the ethical guidelines of the Declaration of Helsinki.

3. Results

The main characteristics of the 2017–2022 development and 2023 test cohorts are summarized in Table 1. The 2017–2022 cohort consisted of 122,754 individuals admitted to ICFR in Catalonia (median age [IQR]= 83.0 [75.0;88.0], 58% women, 80% with low or very low income). The 2023 cohort included 31,640 patients (median age [IQR]= 82.0 [75.0;88.0], 57% women, 75% with low or very low income, 57% showed complete or high disability in the modified ADL function score (<40/100 points)). Median LOS in acute care before ICFR admission was 7 days, Median length of stay in ICFR was 32 days, and roughly two thirds experienced a successful discharge to the community or their previous nursing home (considered as stable people's place of living, in Catalonia). The two cohorts were largely similar in baseline characteristics.

After adjusting for age, sex, and income level, the ICMIs was strongly associated with outcomes, namely the "cost ICMI" with both continuous LOS (beta [95%CI] from linear regression being 1.28 [1.22, 1.33]) and LOS>57 days (OR [95%CI] from logistic regression=13.8 [10.2–18.9]) and the "severity ICMI" with unsuccessful discharge (OR [95%CI]=4.1 [3.8–4.3]).

Fig. 2 shows the AUC of the different multivariable models. The base model, including only age, gender, and income, showed an AUC of 0.55 [0.54–0.57] and 0.55 [0.54–0.55] for LOS and unsuccessful discharge, respectively. The inclusion of the RUG-III score in addition to sociodemographic variables, demonstrated only a slight improvement in predicting LOS or discharge destination, which remained overall poor (AUC 0.56 [0.55–0.56] and 0.59 [0.58–0.59], respectively). A similar small improvement was achieved in the R-squared for continuous length of stay as an outcome. Conversely, when the new ICMIs were added to the model, AUC improved to 0.63 [0.62–0.65] for dichotomous LOS and 0.66 [0.65–0.66] for unsuccessful discharge. The inclusion in the models of the proxies for the previous use of hospital resources showed a slight further improvement of the model performance.

After bootstrap internal validation, the amount of optimism was small, and measures of model performance were largely unchanged, suggesting little overfitting (Table 2).

4. Discussion

Using a comprehensive cohort of older patients admitted to ICFR units in the whole region of Catalonia, we created two new case-mix

Table 1
Summary characteristics, overall and stratified by cohort.

	Overall	2017, 2018, 2019 and 2022	2023
	***N* = 154,394**	***N* = 122,754**	***N* = 31,640**
Sex			
Men	64,848 (42.0%)	51,280 (41.8%)	13,568 (42.9%)
Women	89,546 (58.0%)	71,474 (58.2%)	18,072 (57.1%)
Age (years)	83.0 [75.0;88.0]	83.0 [75.0;88.0]	82.0 [75.0;88.0]
Age groups			
<45	971 (0.63%)	790 (0.64%)	181 (0.57%)
45–64	11,936 (7.73%)	9284 (7.56%)	2652 (8.38%)
65–74	23,517 (15.2%)	18,774 (15.3%)	4743 (15.0%)
75–84	54,068 (35.0%)	43,457 (35.4%)	10,611 (33.5%)
>84	63,902 (41.4%)	50,449 (41.1%)	13,453 (42.5%)
Income level			
High (>100k EU)	328 (0.21%)	239 (0.19%)	89 (0.28%)
Middle (18k-100k EU)	31,534 (20.4%)	23,745 (19.3%)	7789 (24.6%)
Low (<18k EU)	81,051 (52.5%)	67,991 (55.4%)	13,060 (41.3%)
Very low (no income)	41,481 (26.9%)	30,779 (25.1%)	10,702 (33.8%)
Modified Barthel index			
Low dependency	30,194 (19.6%)	25,161 (20.5%)	5108 (16.1%)
Moderate dependency	44,471 (28.8%)	35,945 (29.3%)	8526 (27.0%)
High dependency	47,300 (30.7%)	36,341 (29.6%)	10,947 (34.6%)
Total dependency	32,351 (21.0%)	25,235 (20.6%)	7053 (22.3%)
Primary admission diagnosis			
Hip fracture	18,221 (11.8%)	14,888 (12.1%)	3333 (10.5%)
Stroke	10,869 (7%)	8752 (7.1%)	2117 (6.7%)
Dementia, delirium	8617 (5.6%)	6865 (5.6%)	1752 (5.5%)
Heart failure	7209 (4.7%)	5749 (4.7%)	1460 (4.6%)
Skin ulcers	7089 (4.59%)	5676 (4.62%)	1410 (4.46%)
Dementia (comorbidity)	25,936 (16.8%)	20,612 (16.8%)	5320 (16.8%)
RUG-III	1.00 [0.74;1.17]	1.00 [0.74;1.13]	1.00 [0.81;1.34]
ICMI (cost)	1.02 [0.89;1.13]	1.02 [0.89;1.13]	1.03 [0.89;1.14]
ICMI (severity)	0.95 [0.74;1.21]	0.94 [0.74;1.21]	1.00 [0.78;1.23]
N of hospitalization days (past 6 months)	17.0 [8.00;37.0]	18.0 [8.00;37.0]	15.0 [8.00;33.0]
Hospitalization LOS prior to ICFR (days)	7.00 [0.00;14.0]	7.00 [0.00;14.0]	7.00 [1.00;14.0]
LOS in ICFR (days)	33.0 [18.0;43.0]	33.0 [18.0;43.0]	32.0 [18.0;43.0]
Discharge status			
Alive (home)	106,635 (69.1%)	84,094 (68.5%)	22,860 (72.3%)
Died	11,596 (7.51%)	9454 (7.70%)	2090 (6.61%)
Acute or other intermediate services	36,163 (23.3%)	29,206 (23.8%)	6690 (21.1%)

*For categorical variables, N (%) are provided. For quantitative and symmetric variables, mean (standard deviation). For the remaining quantitative variables, median [IQR] are provided instead.
Legend.
ICFR: Intermediate Care Functional Recovery units.
ICMI: intermediate care case-mix index.
The modified Barthel index was derived from the MDS ADL scale, as detailed in the Methods section, to obtain a 0–100 disability score (ranging from a score of

0 indicating completely disabled and score of 100 indicating completely independent) as in the original Barthel index. Categories: and low or no dependency (≥60 points), moderate (40–59 points), high (20–39 points) and complete dependency (<20 points).

indicators for intermediate care, using only principal admission diagnosis and functional measures. These simplified case-mix indicators slightly improved the prediction of LOS or discharge destination when compared to the existing RUG-III classification system based on the

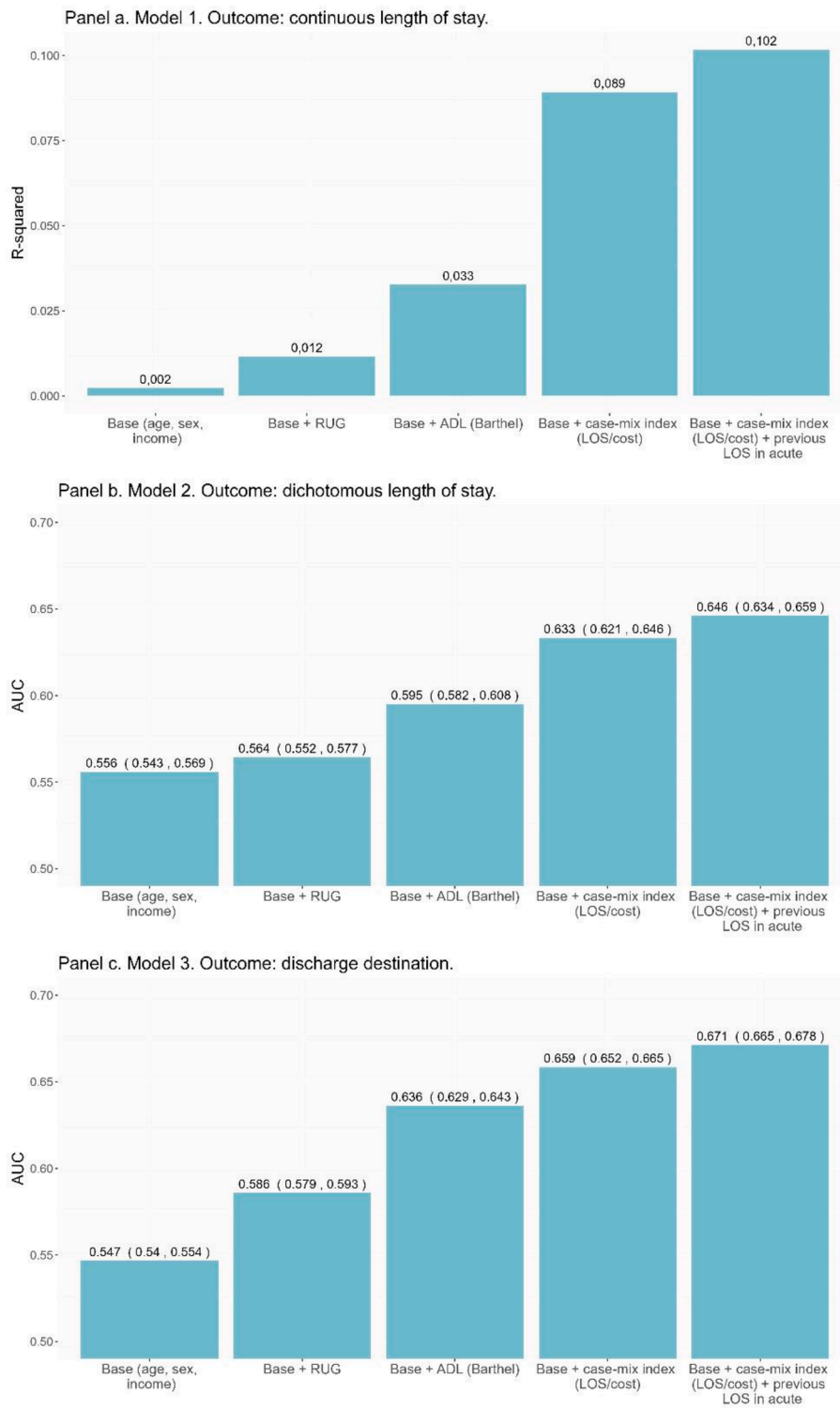


Fig. 2. Result of the performance of the multivariable models.
From left to right, base model, base+RUG-III, base+ADL function, base+geriatric intermediate care case-mix indexes, and base+geriatric intermediate care case-mix indexes+previous days of acute care, respectively. Dichotomous LOS: ≤57 days Vs >57 days (90th percentile of the LOS distribution). R-squared: Proportion of the variance in the dependent variable that is explained by the independent variables in the model (an R-square value close to 1 means a good fit). Area under the receiving-operator curves (AUC): quantification of the ability of the model to correctly rank predictions; the model's ability to distinguish between the positive and negative classes.

Table 2
Results of the bootstrap analysis for the model including base (age, sex, income) + ICMI + previous LOS in acute care.

	Original index	Training	Test	Optimism	Bias-corrected index
Outcome: continuous length of stay					
R-squared	0.1017	0.1019	0.1013	0.0006	0.1011
MSE	0.4661	0.4660	0.4663	−0.0003	0.4664
Intercept	0.0000	0.0000	0.0075	−0.0075	0.0075
Slope	1.0000	1.0000	0.9978	0.0022	0.9978
Outcome: dichotomous length of stay					
AUC	0.6463	0.6474	0.6451	0.0023	0.6440
R2	0.0469	0.0478	0.0461	0.0017	0.0452
Intercept	0.0000	0.0000	−0.0350	0.0350	−0.0350
Slope	1.0000	1.0000	0.9840	0.0160	0.9840
Emax	0.0000	0.0000	0.0103	0.0103	0.0103
Brier	0.0794	0.0793	0.0794	−0.0001	0.0795
Outcome: discharge destination					
AUC	0.6714	0.6716	0.6711	0.0005	0.6710
R2	0.1023	0.1025	0.1020	0.0006	0.1017
Intercept	0.0000	0.0000	−0.0017	0.0017	−0.0017
Slope	1.0000	1.0000	0.9976	0.0024	0.9976
Emax	0.0000	0.0000	0.0008	0.0008	0.0008
Brier	0.1858	0.1857	0.1858	−0.0001	0.1859

The outcome of continuous length of stay was modeled using linear regression. The outcome of dichotomous length of stay was modeled using logistic regression (>57 days vs. ≤57 days). The outcome of discharge destination was modeled using logistic regression (death or transfer to other healthcare resources versus home or nursing home).
R-squared: Measures the proportion of the variance in the dependent variable that is explained by the independent variables in the model. An R-square value close to 1 means a good fit.
MSE: The mean squared error is a measure of the average squared differences between the observed values and the predicted values. It penalizes large errors more than small ones. A lower MSE indicates a better fit.
AUC: Quantifies the ability of the model to correctly rank predictions; the model's ability to distinguish between the positive and negative classes.
R2: The Nagelkerke R2 index is an adjusted version of the Cox & Snell R-square that adjusts the scale of the statistic to cover the full range from 0 to 1. This pseudo-R2 statistic measures the improvement in the fitted model compared to the null model. A value close to 1 is desirable.
Emax: The maximum difference between raw predicted probabilities, and the recalibrated probabilities.
Brier: The mean square error between predictions and observations. The Brier score is a strictly proper scoring rule. A score near 0 is desirable.

comprehensive MDS. However, the main driver for creating the new index was not improving discrimination but providing simpler tools for professionals, closer to routine assessment instruments from the clinical practice, without losing discrimination. These simplified measures were specifically developed to facilitate adoption within the Catalan healthcare system.

We found that functional status and principal admission diagnosis were important prognostically in predicting LOS and adverse outcomes following admission to intermediate care. These results are in line with previous studies investigating which baseline characteristics better predicted LOS or mortality at discharge from traditional hospitals [13]. From these studies which have largely been conducted in the USA, UK, or Australia, functional status emerges as one of the main drivers of complexity in frail older adults. Similar studies focused specifically on the post-acute care and geriatric rehabilitation setting have found that functional status is an important prognostic factor for adverse outcomes, in some cases more than admission diagnosis ([22–24]). Our results extend these findings to ICFR units in Catalonia, confirming the importance of including functional status in a case-mix index for risk-adjustment.

In our study, a model including age, sex, income, ICMI (based on admission diagnosis and functional status), and previous acute-care use predicted ICFR length of stay and discharge destination with modest discrimination. This is similar to previously published prognostic models for older adults receiving post-acute care in skilled nursing facilities in the USA, a setting that is similar to the intermediate care centers of Catalonia. For example, Burke et al. [25]. showed, in 2043 older adults, that a composite risk score, including functional status, comorbidities, the use of indwelling catheter and hospital LOS, predicted readmissions, mortality, and LOS in SNF with an AUC of 0.75). Another US study of 9803 individuals admitted to SNFs associated with Mayo Clinic (2009–2016), showed that age, comorbidities, mobility at discharge, and previous use of healthcare resources, predicted mortality and hospital readmissions with an AUC of 0.81 and 0.69, respectively [26,27].

When compared to other instruments, such as the Diagnosis Related Groups (DRGs), commonly used in acute care, functional status achieved better results in predicting similar outcomes in subacute and non-acute services in Australia [28]. This might possibly relate with the nature of DRG, developed in and for acute care and based on classical procedures of acute care interventions.

In a Finnish study on patients attended in post-acute care, which used the InterRAI-PAC tool (an evolution of the original MDS into different sets of comprehensive geriatric assessment tools, which allow calculating the RUG), the best instruments for predicting prolonged hospital stay and in-hospital mortality were the frailty indexes (expressing the sum of the accumulated deficits of the person) and the ADL scale included in the tool [29]. Regarding the use of RUG-III, a previous study with a large sample size of Medicare and Medicaid patients admitted to 150 certified SNFs in 12 USA states, concluded that RUG-III explained only 10.4% of the variance in costs per diem [30]. This is coherent with the eventual modification of rules for the reporting and reimbursement system in USA SNFs [12].

This work serves as a cornerstone for a new policy aimed at adopting more agile, clinically relevant, and reliable datasets as the foundation for continuously assessing the performance of public contract providers in Catalonia. The existing MDS in Catalonia is time-consuming and diverges from the tools usually implemented by professionals in routine care. Also, the RUG-III classification system is based on data from another country more than three decades ago and shown in prior work to explain relatively of the variance in costs per diem. In the US, RUG-III was replaced by an updated RUG-IV and ultimately by the Patient Driven Payment Model, which was designed to focus on clinically relevant factors. The creation of new case-mix indicators specific to individuals receiving intermediate care in Catalonia, using updated data and a simplified version of the Minimum Data Set (MDS), is expected to have diverse applications for the healthcare system of Catalonia, including:

i). assigning a relative weight to each provider based on the summary case-mix indices from the previous year, enabling a ranking system that forms the basis for a 3% variable reimbursement tied to the complexity of the attended case-mix. This ranking and reimbursement system has been in place for three decades, based on RUG-III scores up to the moment.
ii). supporting transparent benchmarking through the "Results Central" initiative and portal of the Agency for Health Quality and Assessment of Catalonia (AQuAS), with a specific focus on intermediate care [31].
iii). serving as a foundation for future public policy and decision-making by the healthcare administration.

To ensure the reliability of the simplified MDS, routine, independent data quality audits will be implemented. Ultimately, we envision that a streamlined and more reliable dataset—encompassing diagnoses, procedures, ADL function, and potentially other relevant geriatric syndromes—will enable the public administration to obtain higher-quality data and progressively improve the performance of predictive models

A primary strength of our study is the use of a large, comprehensive

dataset, which includes all admissions to ICFR units in Catalonia. This represents a real-world and heterogeneous population, comprised of many older adults with multimorbidity and frailty. The validation of our models through bootstrapping additionally showed little evidence of overfitting. A few limitations should be noted. First, our data collection was based on the existing variables included in the routine mandatory data report of Catalonia, so that a limited set of variables and a degree of heterogeneity in data collection might influence the results. Second, the performance of our models was relatively modest in predicting the pre-selected outcomes. However, based on previous studies using smaller and possibly more selected samples, the prediction of LOS and other outcomes rarely achieved high model performance (with AUCs typically in the 0.7 range). Our results suggest that our new case-mix indicators predict proxies for cost and discharge destination better than previous tools used in Catalonia (MDS-RUG-III) and is simpler for busy healthcare professionals. It is possible that other low-burden predictors could enhance the performance, but we based our study on the available, reliable variables in our system. Finally, while our model showed little optimism upon internal validation, external validation of the model should be conducted if used in settings outside of our intended setting. Additionally, we plan to conduct continual assessments in the sample population using updated data to identify any changes in model performance over time and consider updating the model.

In conclusion, our results suggest that a new simplified dataset, based primarily on admission diagnosis and functional status, improves the prediction of length of stay and discharge destination among individuals admitted to ICFR units in Catalonia, compared to the existing tool, the MDS-RUG-III. Our results can help inform broader efforts within the healthcare system of Catalonia to improve intermediate care in Catalonia.

Funding

This work was developed using internal funding of the Department of Health of the Government of Catalonia, Spain.

Dr. Deardorff was supported by the following grants from the National Institute on Aging: R03AG082859, K76AG094730, P30AG044281.

Declaration of the use of generative AI and AI-assisted technologies in scientific writing and in figures, images and artwork

The authors declare no use of generative AI in the manuscript preparation process upon submission of the paper.

Data statement

The data that support the findings of this study are stored at the central repositories of the Catalan Health Service, and are available from the authors, following the protocols established by the Catalan Health Service, upon reasonable request due to privacy and ethical restrictions.

CRediT authorship contribution statement

M Inzitari: Writing – original draft, Validation. **E Vela:** Formal analysis, Data curation. **C Martín Pardina:** Formal analysis, Data curation. **E Vallés:** Validation. **L Viale:** Validation. **G Valls:** Validation. **M.A Gil:** Validation. **M Llonch:** Validation. **K Covinsky:** Validation. **J Deardorff:** Validation.

Acknowledgments

The authors declare no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tjfa.2026.100158.

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