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Featured Article

How frailty and nursing complexity interact and prolong hospital stays in heart failure patients: a retrospective multicentric observational study

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ABSTRACT

This study aimed to examine frailty and nursing complexity at hospital admission in patients with heart failure (HF) and to explore their individual and joint associations with length of stay (LOS). A retrospective multicentric observational study was conducted among adult patients with HF admitted to two Italian university hospitals between January 1 and December 31, 2022. Frailty was estimated using the Blaylock Risk Assessment Screening Score (BRASS), while nursing complexity was measured by the number of nursing diagnoses (NDs) at admission. Prolonged LOS was defined as hospital stays exceeding the 75th percentile. Data were extracted from the hospital discharge register and the Professional Assessment Instrument and analyzed using correlation analyses, latent class analysis (LCA), and logistic regression models. Among 1712 patients, 26.6% experienced prolonged LOS. Frailty was positively associated with nursing complexity (r = 0.245, 95% CI: 0.196–0.288), and both frailty (r_s = 0.236; 95% CI: 0.192–0.281) and nursing complexity (r_s = 0.232; 95% CI: 0.187–0.278) were associated with LOS. LCA identified two admission profiles: low frailty/low nursing complexity and high frailty/high nursing complexity. Membership in the high frailty/high nursing complexity profile was associated with higher odds of prolonged LOS in unadjusted model (OR = 2.805, 95% CI: 2.223–3.541; $p < 0.001$), and remained significant after adjustment for age, sex, comorbidities, and DRG weight (OR = 1.939, 95% CI: 1.354–2.776; $p < 0.001$). Joint assessment of frailty and nursing complexity at hospital admission may support early identification of HF patients at risk for prolonged LOS.

Introduction

Heart failure (HF) is a chronic condition that poses significant challenges to healthcare systems, affecting >64 million people globally and being associated with high morbidity and mortality rates.[1] In Italy, HF prevalence increases substantially with age—from approximately 1 % in adults aged 45–55 years to >10 % in those aged ≥80 years—and accounts for a substantial proportion of hospital admissions.[2] As a result, HF represents one of the main drivers of frequent and prolonged hospitalizations.[3,4]

Hospital stays for HF patients are particularly challenging due to the interaction of disease progression, acute decompensations, comorbid conditions, and treatment-related issues.[5] Within this context, hospital length of stay (LOS) represents a key outcome in HF care, serving as a proxy for patients' care needs and healthcare resource utilization.[4,6]

Among the factors influencing LOS in HF frailty has gained increasing attention as a multidimensional syndrome characterized by diminished physiological reserves and increased vulnerability to both internal and external stressors.[7,8] Frailty develops through the interaction of aging, comorbidities, and HF-related symptoms.[9] In patients with HF, frailty has been consistently associated with poorer treatment tolerance, delayed recovery, increased care demands during hospitalization, and prolonged LOS.[10,11]

Alongside frailty, nursing complexity represents another key determinant of hospitalization outcomes, including LOS.[12-14] Nursing complexity is generally conceptualized as a multidimensional construct reflecting patients' care needs and care intensity,

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but it has been operationalized through heterogeneous clinical and administrative indicators, reflecting the lack of a shared definition in the literature.[15-17] Within this heterogeneous landscape, several studies have identified nursing complexity using nursing-related indicators, such as the number of nursing diagnoses (NDs) documented at hospital admission, as a pragmatic way to capture patients' care needs in routine clinical settings.[14,17,18] In patients with HF, prevalent NDs—including deficient knowledge, activity intolerance, decreased cardiac output, risk for infection, and self-care deficits—reflect complex care needs that may contribute to prolonged hospitalizations.[19-21]

Although frailty and nursing complexity have each been identified as determinants of LOS, existing studies have largely examined these dimensions separately. Evidence linking frailty to prolonged LOS is substantial,[10,22,23] and a growing body of research has also demonstrated an association between higher nursing complexity and longer hospitalization.[12-14,17] However, their interrelationship and combined contribution to LOS in hospitalized patients with HF remain insufficiently explored. In particular, it is unclear whether distinct admission patterns of frailty and nursing complexity identify patients at increased risk of prolonged LOS. This gap limits a comprehensive understanding of LOS in HF, as frailty and nursing care-related dimensions have rarely been examined jointly alongside traditional clinical indicators.

Accordingly, this study aims to examine frailty and nursing complexity at hospital admission in patients with HF and to explore their individual and joint associations with LOS, including prolonged LOS. Specifically, the objectives are to: 1) describe the prevalence of frailty and nursing complexity in hospitalized patients with HF; 2) examine the associations between frailty, nursing complexity, and LOS, and 3) evaluate whether profiles characterized by co-occurring high frailty and high nursing complexity are associated with prolonged LOS.

Methods

Design

Retrospective, multicentric, observational study.

Study setting, sampling and inclusion criteria

The study was conducted at two Italian university hospitals: one large hospital with 1611 beds and 266 care units, and a smaller facility with 166 beds and 6 care units.

The sample included all clinical records of adult patients (aged ≥ 18 years) diagnosed with HF, identified by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code 428.xx,[24] and consecutively admitted between January 1 and December 31 in 2022. To minimize bias related to recurrent admissions, only the first hospitalization (index hospitalization) per patient during the study period was considered.[25] Admissions with a LOS <2 days were excluded, as they are comparable to day-hospital or short stay admissions and do not reflect standard inpatient care pathways. LOS was considered completed at the time of discharge or in-hospital death.[17]

The present study expands a preliminary monocentric conference abstract published by the authors[26] by adopting a multicentric design, analyzing an expanded dataset, and including bivariate analyses, latent class model comparison, and adjusted regression models (see Data analyses section). The study adhered to the Reporting of studies Conducted using Observational Routinely-collected Data (RECORD) statement.[27]

Data collection, variables, and measurement tools

To conduct this study, several variables were analyzed, as described below.

Frailty

Frailty was estimated through the Blaylock Risk Assessment Screening Score (BRASS).[28] BRASS is a discharge-planning screening tool designed to identify hospitalized patients at risk of complex discharge needs and care transitions. Because BRASS captures multidimensional vulnerability domains overlapping with frailty constructs (e.g., functional status, cognitive vulnerability, medical complexity, and social support), it was used as a pragmatic proxy of frailty risk at hospital admission. The Italian version of BRASS has demonstrated acceptable reliability and predictive validity.[29] BRASS categorizes patients into low (<10), moderate (10−19), and high (≥20) risk levels. BRASS is routinely collected and available in the study hospitals' electronic health record.

Nursing complexity

Nursing complexity was operationalized as the number of NDs documented within the first 24 h from admission, reflecting patient's care needs[14,17,18] NDs were documented using the Professional Assessment Instrument (PAI), a clinical nursing information system (CNIS) embedded in the electronic health record and supporting standardized nursing documentation through a validated decision-support algorithm[30] which demonstrated good content validity and reliability in linking assessment findings in accurate NDs. Nurses can accept, reject, or add NDs based on clinical judgment. At the time of data collection, PAI used the Clinical Care Classification (CCC) System, which was translated and cross-culturally adapted into Italian with evidence of satisfactory validity and reliability.[31] Nurses in the study settings have been routinely trained in standardized nursing documentation, with regular updates and institutional monitoring of documentation quality.

Administrative and clinical variables

Administrative and clinical variables were extracted from the hospital discharge register (HDR), the mandatory national discharge dataset in Italy. Extracted data included sociodemographic characteristics (age, sex, education, marital status), admission and discharge disposition, LOS, and discharge diagnoses coded using the ICD-9-CM, 9th Revision (2007 version), the mandatory national coding system in Italy. Patients were classified as medical or surgical based on the occurrence of a surgical procedure during the index admission. DRG weight was used as a proxy of medical severity and resource consumption, with higher values indicating greater expected use of hospital resources.[32] Comorbidity burden was quantified as the number of ICD-9-CM diagnosis codes recorded for each patient.

Outcome measure

Prolonged LOS was determined using a percentile-based methodology and was defined as any LOS exceeding the 75th percentile of the LOS distribution in the study cohort.[14]

Data analyses

Descriptive statistics summarized demographic, clinical, and organizational characteristics. Continuous variables (e.g., age, BRASS score, LOS, and DRG weight) were reported as means and standard deviation (SD) if normally distributed, otherwise as median and interquartile range (IQR). Categorical variables (e.g., sex, marital status, admission modality, discharge disposition, and prevalence of NDs) were presented as frequencies and percentages. Normality was assessed using skewness and kurtosis (cut-offs ± 2 and ± 7, respectively).[33] Associations between continuous variables were examined using Pearson's correlation coefficient (r) for normally distributed variables and Spearman's rank correlation coefficient (r_s) for non-normally distributed variables. Correlation strength was interpreted using established thresholds, and 95 % confidence intervals (95 % CIs) were reported to support effect size interpretation.[34] NDs were defined at high frequency when their prevalence was ≥ 20 %.[17]

Bivariate comparisons between patients with prolonged LOS and non-prolonged LOS were performed using Student's *t*-test for approximately normally distributed data; otherwise, the Mann-Whitney *U* test was applied. The Chi-squared test or Fisher's exact test (as appropriate) was used to evaluate associations between frailty levels and categorical variables. For comparisons across frailty categories, one-way ANOVA was conducted for approximately normally distributed data (e.g., to compare the mean number of NDs across frailty levels—low, moderate, and high); otherwise, the Kruskal-Wallis H test was applied (e.g., LOS and DRG weight metrics across frailty classes). Tukey's Honest Significant Difference (HSD) test was used for post-hoc pairwise comparisons.

Latent Class Analysis (LCA) was conducted to identify latent profiles based on BRASS scores and number of NDs as continuous manifest indicators, incorporating number of comorbidities and DRG weight as covariates to support class characterization and separation. Covariates were included using a one-step approach (i.e., included directly in the latent class model and estimated simultaneously with membership). Models with two to four classes were estimated and compared. Model fit was evaluated using log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC), and entropy.[35] Entropy was interpreted as a descriptive index of classification precision rather than as a criterion for selecting the number of classes. Model convergence and class size distribution were examined to avoid over-extraction and unstable solutions.

Binary logistic regression examined the association between LCA-derived profile membership and prolonged LOS. The primary model was unadjusted (profile membership only); as sensitivity analysis, an adjusted model included profile membership and key covariates (age, sex, number of comorbidities, and DRG weight). Multicollinearity was assessed using variance inflation factors (VIF). Results were expressed as odds ratios, with 95 % confidence intervals. All statistical analyses were performed using IBM SPSS *Statistics*® for Mac OS, Ver. 29 (Armonk, NY, USA: IBM Corp.) and the *glca* package in R statistical software (version 4.1; R Core Team), with statistical significance set at $p < 0.05$.

Ethical considerations

Ethical approval for this study was obtained by the Catholic University of the Sacred Heart (Prot. 0012,915/24, approved on 16th May 2024), in accordance with the Declaration of Helsinki and good clinical practice. At hospital admission, patients provided consent for data processing and analysis. They were subsequently contacted by mail or phone to receive written informed consent and to receive detailed information about the study, including its purpose, the use of anonymized data, the minimal associated risks, and their rights, such as the option to withdraws consent at any time; patients not reachable after three attempts within three months were excluded. All data were anonymized by the hospitals' data warehouse prior to analysis, and access to the anonymized dataset was restricted to authorized researchers only. In accordance with the institutional procedure regulating the involvement of healthcare staff in research activities, those whose routinely collected clinical documentation contributed to the dataset were formally informed about the secondary use of such data and provided supplementary consent, as required by institutional policies to ensure transparency, professional protection, and compliance with privacy and workplace regulations.

Results

Characteristics of the study population stratified by frailty risk classes

A total of 1712 HF patients met the inclusion criteria and were considered in this study (Table 1), after excluding 28 patients due to lack of consent. Patients had an average of 76.75 ± 13.69 years and were mainly male (n = 1016, 59.3 %). Among patients who declared their education, the most common level was upper secondary school diploma (19 %). Most patients were married (42.8 %) and the majority of admissions were urgent, with 77.7 % of patients hospitalized through the emergency department. *Left heart failure* was the most frequent HF diagnosis (38.0 %). The distribution of HF diagnoses in the study population is reported in Supplementary Table S1. Medical DRG classifications accounted for 67.4 % of the cases and patients were characterized by a median DRG weight of 1.2605 (IQR: 1.1069) (range: 0.5520 − 12.4289). The median LOS was 10 days (IQR: 11), and 26.6 % of patients (n = 456) experienced a prolonged LOS (LOS ≥ 17 days, corresponding to the 75th percentile). At discharge, most patients returned home (74.0 %) and 11.6 % died during hospitalization.

The mean BRASS score was 10.57 ± 7.55 (range: 0 - 36). The majority of patients were categorized as having low frailty (BRASS <10) (60.0 %, n = 1027). Patients with increasing frailty risk were significantly older, with a mean age progressively rising across frailty categories (F = 135.185, $p < 0.001$). Educational levels demonstrated distinct patterns among frailty classes, while marital status revealed a higher prevalence of widowed patients in the high frailty group (16.9 %) compared to the low frailty group (6.1 %, $p < 0.001$). Clinically, patients in higher frailty categories exhibited more comorbidities (F = 169.179, $p < 0.001$) and were more frequently admitted urgently through the emergency department ($p < 0.001$). In terms of DRG classification, medical DRGs were more common in the high frailty group than in the low frailty group (89.8 % vs. 56.7 %, $p < 0.001$). LOS also varied significantly across frailty classes [x^2 = 92.938, $p < 0.001$], with a median stay of 13 days in the high frailty group, compared to 9 days in the low frailty group. Finally, statistically significant differences in DRG weights were found among frailty groups [x^2 = 31.579, $p < 0.001$]. Although higher frailty levels were associated with prolonged LOS, this did not consistently correspond to increased DRG weights.

Prevalence of nursing complexity across frailty classes

A total of 8742 NDs were identified in the study population, with a mean of 5.11 ± 3.64 NDs per patient at admission (range 1 − 17). The distribution of NDs stratified by frailty classes is reported in Supplementary Table S2. Most NDs differed significantly across frailty groups ($p < 0.05$). The most prevalent ND in the low frailty group was *Acute pain* (54.5 %), whereas *Fall risk* was the most frequent diagnosis in the moderate frailty group (64.5 %). In the high frailty group, *Infection risk* was the most prevalent ND (65.7 %) and remained highly frequent across all frailty classes.

Beyond the leading diagnoses, the high frailty group was characterized by a high prevalence of mobility- and safety-related NDs, with *Physical mobility impairment* (54.7 %) ranking third and *Skin integrity impairment risk* (40.6 %) ranking fourth. Disturbances related to rest-activity patterns were also prominent, with *Sleep pattern disturbance* affecting 37.8 % of patients. Alterations in elimination and nutrition were frequent, including *Urinary elimination alteration*

Table 1
Patient characteristics of the study population stratified by frailty risk classes.

	General Population (N = 1712)		Low Frailty (n = 1027)		Moderate Frailty (n = 431)		High Frailty (n = 254)		p-value[a]
				Descriptive Statistics					
Variable									
Age (mean, SD)	76.73	13.74	72.78	13.02	81.01	13.97	85.56	8.67	< 0.001
Sex (n, %)									< 0.001
Male	1016	59.3	691	67.3	210	48.7	115	45.3	
Female	696	40.7	336	32.7	221	51.3	139	54.7	
Education (n, %)									< 0.001
No education	44	2.6	22	2.1	16	3.7	6	2.4	
Primary school	229	13.4	114	11.1	80	18.6	35	13.8	
Lower secondary school	294	17.2	189	18.4	64	14.8	41	16.1	
Upper secondary school	325	19.0	225	21.9	63	14.6	37	14.6	
Bachelor's degree	155	9.1	99	9.6	38	8.8	18	7.1	
Not declared	665	38.8	378	36.8	170	39.4	117	46.1	
Marital status (n, %)									< 0.001
Single	131	7.7	87	8.5	32	7.4	12	4.7	
Married	732	42.8	477	46.4	175	40.6	80	31.5	
Separated	51	3.0	36	3.5	8	1.9	7	2.8	
Divorced	21	1.2	16	1.6	3	0.7	2	0.8	
Widowed	165	9.6	63	6.1	59	13.7	43	16.9	
Not declared	612	35.7	348	33.9	154	35.7	110	43.3	
Modality of admission (n, %)									< 0.001
Urgent from ED	1331	77.7	707	68.8	380	88.2	244	96.1	
Scheduled	381	22.3	320	31.2	51	11.8	10	3.9	
Comorbidities (mean, SD)	4.66	1.86	4.06	1.80	5.36	1.60	5.91	1.45	< 0.001
DRG classification (n, %)									< 0.001
Medical	1154	67.4	582	56.7	344	79.8	228	89.8	
Surgical	558	32.6	445	43.3	87	20.2	26	10.2	
DRG weight (median, IQR)	1.2605	1.1069	1.2952	1.1544	1.2243	0.7342	1.2424	0.5038	< 0.001
LOS (median, IQR)	10.00	11	9.00	9	13.00	14	13.00	15	< 0.001
Prolonged LOS (n, %)									< 0.001
No	1256	73.4	825	80.3	275	63.8	156	61.4	
Yes	456	26.6	202	19.7	156	36.2	98	38.6	
Discharge disposition (n, %)									< 0.001
Home	1267	74.0	887	86.4	275	63.8	105	41.3	
Transferred to other healthcare facilities (inter-hospital patient transfer)	33	1.9	10	1.0	15	3.5	8	3.1	
Voluntary (patient's decision, against medical advice)	20	1.2	14	1.4	6	1.4	-	-	
Transferred to other care setting (rehabilitation or home care)	193	11.3	69	6.7	66	15.3	58	22.8	
Died	199	11.6	47	4.6	69	16.0	83	32.7	

Legend: DRG, Diagnosis Related Group; ED, emergency department; IQR, interquartile range; LOS, length of stay; SD, standard deviation.
[a] Chi-squared test, Fisher's exact test for categorical variables; ANOVA or Kruskal-Wallis test for continuous variables, as appropriate.

(34.6 %) and *Body nutrition deficit* (33.9 %), both ranking among the top ten diagnoses. Safety related conditions remained highly prevalent, with *Injury risk* observed in 32.3 % of patients. In addition, functional dependence was reflected by a substantial presence of self-care deficits, particularly *Bathing/hygiene deficit* (28.3 %), *Toileting deficit* (22.4 %), *Feeding deficit* (20.9 %), and *Dressing/grooming deficit* (9.1 %).

Consistently, the mean number of NDs increased significantly across frailty categories (low: 4.47 ± 3.52; moderate: 5.76 ± 3.60; high: 6.56 ± 3.57; F = 44.947; $p < 0.001$), with all post-hoc pairwise comparisons reaching statistical significance ($p < 0.05$).

Relationship between frailty, nursing complexity, and length of stay

The analyses revealed significant positive correlations between BRASS, NDs, and LOS. Specifically, BRASS showed a weak positive correlation with the number of NDs (r = 0.245, 95 % CI [0.196–0.288], $p < 0.001$) and with LOS (r_s = 0.236, 95 % CI [0.192–0.281], $p < 0.001$). Similarly, the number of NDs was weakly correlated with LOS (r_s = 0.232, 95 % CI [0.187–0.278], $p < 0.001$).

Patients with prolonged LOS exhibited significantly higher BRASS scores and a higher number of NDs compared to those without prolonged LOS (BRASS score: 12.90 ± 7.77 vs. 9.73 ± 7.30; NDs 6.32 ± 3.76 vs. 4.67 ± 3.49; both $p < 0.001$). In the same bivariate comparisons, patients with prolonged LOS were significantly older and had significantly higher comorbidity burden and DRG weight (Table 2).

Profiles of frailty and nursing complexity

Latent class models with two to four classes were estimated. The two-class solution was retained based on model fit indices, class size distribution, and interpretability. Compared with the 3– and 4– class solutions, the 2–class model showed the lowest AIC and BIC, and avoided small classes (smallest class: 45.9 % vs. 21.3 % and 13.5 %, respectively). Detailed model fit statistics for the 2–4 class solutions are reported in Supplementary Table S3.

In the selected two-class model (N = 1712), Class 1 (high frailty/high nursing complexity) included 54.1 % of patients (n = 932), while Class 2 (low frailty/low nursing complexity) accounted for 45.9 % (n = 780). Entropy for the two-class solution was 0.628, indicating moderate separation between profiles. Model fit indices for the selected solution were as follows: log-likelihood −9609, AIC = 19,436, BIC = 20,029, and G^2 = 11,395.

As expected, the two classes differed in the manifest indicators used to derive the profiles. Specifically, Class 1 showed a higher mean number of NDs than Class 2 (6.23 ± 3.47 vs. 3.76 ± 3.37; $t(1710)$ =14.89; $p < 0.001$), and a higher mean BRASS score (15.01 ± 7.33 vs. 5.27 ± 3.06; $t(1710)$ =34.65; $p < 0.001$).

Table 2
Bivariate comparisons between patients with normal and prolonged LOS.

Variable	Normal LOS		Prolonged LOS		p-value[a]
	Descriptive Statistics				
Age (mean, SD)	76.09	14.19	78.55	12.03	<0.001
Sex (n, %)					0.029
Male	765	60.9	251	55.0	
Female	491	39.1	205	45.0	
Comorbidities (mean, SD)	4.31	1.82	5.64	1.63	<0.001
DRG weight (median, IQR)	1.2243	1.2163	1.6432	1.3853	<0.001
BRASS Score (mean, SD)	9.73	7.30	12.90	7.77	<0.001
Number of NDs (mean, SD)	4.67	3.49	6.32	3.76	<0.001

Legend: LOS, length of stay; DRG, Diagnosis Related Group; BRASS, Blaylock Risk Assessment Screening Score; NDs, nursing diagnoses.
Note: Continuous variables were compared using the Mann–Whitney U test or Student's *t*-test, as appropriate. Categorical variables were compared using the chi-square test.

Relationship between high frailty/high nursing complexity profile and prolonged length of stay

Logistic regression analysis showed that membership in the high frailty/high nursing complexity profile (Class 1) was associated with higher odds of prolonged LOS compared with the low/frailty/low nursing complexity profile (Class 2).

In the unadjusted model (Model 1), Class 1 membership was associated with higher odds of prolonged LOS (OR = 2.805, 95 % CI [2.223–3.541], $p < 0.001$). In the adjusted model (Model 2), this association remained significant after adjustment for age, sex, number of comorbidities, and DRG weight (OR = 1.939, 95 % CI 1.354–2.776; $p < 0.001$) (Table 3).

Discussion

This multicentric study shows that frailty-related vulnerability and nursing complexity assessed at hospital admission are jointly associated with LOS and prolonged LOS in patients with HF.

Frailty prevalence in our cohort was lower than reported in several HF studies,[36] highlighting heterogeneity in frailty operationalization and case-mix across settings. Different frailty instruments capture overlapping but non-identical constructs and should not be considered interchangeable, supporting the need for standardized evaluation frameworks.[37] In this study, frailty was estimated using the BRASS score as a pragmatic proxy of multidimensional vulnerability available at admission, which emphasizes functional status, social support, and medical complexity.[29] Because BRASS is not HF-specific, our estimates should be interpreted as "frailty-risk/vulnerability" rather than as a direct HF frailty phenotype, which may partly explain differences in prevalence compared with HF-specific frailty instruments. Future studies should replicate these analyses using frailty tools validated in HF populations, alongside continued efforts to refine and validate HF-specific frailty assessment tools.[38]

The use of standardized nursing data collected through the PAI system allowed for a structured description of nursing complexity at hospital admission.[39] Although nursing complexity is a multidimensional construct, the number of NDs represents a pragmatic indicator of care needs routinely available in clinical practice. While previous studies have described NDs in HF populations,[19-21] our study extends existing evidence by examining nursing complexity in a large multicentric cohort using a standardized taxonomy (CCC). Stratifying NDs by frailty levels further highlighted how nursing care priorities vary across vulnerability profiles. In particular, the higher prevalence of functional dependency-related NDs in the high-frailty group is consistent with frailty models linking reduced reserves to increased care demands during acute hospitalization and increased need for support with mobility, self-care, and safety-related care processes.[40-42]

Consistent with expectations, higher frailty was associated with higher nursing complexity, with a predominance of NDs related to functional impairment and dependency. However, the association between frailty and nursing complexity was modest, indicating that these dimensions are related but distinct components of hospitalization complexity. This finding is clinically plausible as patients with

Table 3
Binary logistic regression to identify the impact of high frailty/high nursing complexity profiles on prolonged LOS.

Model 1 (unadjusted)								
Variable	**β Coefficient**	**SE**	**Wald**	**df**	***p*-value**	**OR Exp(B)**	**95 % CI (Lower)**	**95 % CI (Upper)**
Constant	−1.637	0.097	285.054	1	< 0.001	0.194		
High frailty/high nursing complexity profile (Class 1)	1.032	0.119	75.447	1	< 0.001	2.805	2.223	3.541
Model 2 (adjusted)								
Variable	**β Coefficient**	**SE**	**Wald**	**df**	***p*-value**	**OR Exp(B)**	**95 % CI (Lower)**	**95 % CI (Upper)**
Constant	−4.100	0.433	89.855	1	< 0.001	0.017		
High frailty/high nursing complexity profile (Class 1)	0.662	0.183	13.078	1	< 0.001	1.939	1.354	2.776
Age	−0.002	0.005	0.104	1	0.747	0.998	0.988	1.008
Sex	0.100	0.124	0.650	1	0.420	1.105	0.867	1.408
Comorbidities	0.397	0.045	77.345	1	< 0.001	1.487	1.361	1.625
DRG weight	0.370	0.044	72.197	1	< 0.001	1.448	1.330	1.577

Legend: LOS, length of stay; β, regression coefficient; SE, standard error of the coefficient; Wald, wald chi-square statistic; df, degrees of freedom; *p*-value, statistical significance of the predictor; OR, odds ratio; Exp(B), exponential function of the coefficient B; CI, confidence interval; DRG, Diagnosis Related Group.
Note: Latent class membership was entered into the regression model as a binary variable (1 = high frailty/high nursing complexity profile; 0 = low frailty/low nursing complexity [reference]).
The outcome variable (prolonged LOS) was coded as 1 = yes and 0 = no.
Model 1 reports the unadjusted association, whereas Model 2 reports a sensitivity analysis adjusted for age, sex, number of comorbidities, and DRG weight.

similar frailty risk may differ substantially in nursing care needs due to symptom burden, cognitive status, mobility, or safety risks[43–45] which are only partly captured by frailty-risk screening. Frailty therefore reflects clinical vulnerability[8,9] while incompletely capturing the heterogeneity of nursing care demands observed during hospitalization.

Frailty and nursing complexity showed weak but consistent positive associations with LOS, in line with prior studies examining these factors separately.[10,12-14,17,22,23,46] The limited magnitude of these associations is expected, as LOS is influenced by multiple patient-related and organizational factors beyond frailty and care needs, including in-hospital complications, diagnostic/therapeutic pathways, discharge barriers, and availability of post-acute services as well as local discharge planning capacity and bed flow pressures.[47–49] Nursing complexity appears to contribute to LOS as one component of a broader hospitalization profile, complementing traditional clinical indicators. Our findings add to the limited evidence jointly considering frailty and nursing complexity at hospital admission using routinely collected data.

Using LCA, we identified two admission profiles characterized by low frailty/low nursing complexity and high frailty/high nursing complexity. Although intuitive, the value of the LCA lies in formally identifying co-occurring vulnerability and care-need patterns and quantifying their association with prolonged LOS. Patients in the high frailty/high nursing complexity profile had higher odds of prolonged LOS, even after adjustment for age, sex, comorbidities, and DRG weight. This suggests that the joint profile captures an admission pattern not fully explained by demographic characteristics or DRG-based severity proxies alone. Given the moderate entropy, profiles should be interpreted as pragmatic groupings rather than sharply distinct patient types and viewed as hypothesis-generating.

An additional finding was that higher frailty was not consistently associated with higher DRG weight, despite both being related to prolonged LOS. This discrepancy is clinically plausible, as DRG weight primarily reflects coded diagnoses and procedures, and may be relatively insensitive to functional dependence, cognitive vulnerability, and social support needs,[16] which are captured by frailty-related vulnerability (in the context of BRASS evaluation) and nursing complexity.[29] These findings suggest that hospital resource utilization is influenced by both medical severity and care-related complexity. Consistently, in our cohort higher frailty levels were associated with less favorable discharge patterns and increased in-hospital mortality, suggesting that vulnerability dimensions shape trajectories beyond what is captured by DRG weights alone.

Clinical implications should be interpreted conservatively. Our results do not imply causality, and the associations are modest; however, they suggest that integrating a frailty-risk/vulnerability score (such as BRASS) with standardized nursing data (i.e., NDs) at admission may support early risk stratification, care planning, and discharge preparedness. Future research should test whether the integration of frailty-related vulnerability and nursing complexity at admission enhances risk stratification and informs early interventions—such as mobility promotion and support, delirium prevention, and discharge coordination—that are potentially actionable within the early phase of hospitalization.[7,50]

Strength, limitations and future directions of the work

Key strengths of this study include its multicentric design, large sample size, and the use of routinely collected, standardized nursing and clinical data. Nevertheless, some limitations should be acknowledged. The retrospective nature of the study limits causal inference and the use of specific assessment systems (BRASS and PAI) may limit the generalizability of the findings to settings that use different tools for evaluating frailty and nursing complexity. Although the PAI provides structured decision support, nurses retain full autonomy in accepting, rejecting, or adding NDs; therefore, some degree of documentation bias related to clinical judgment cannot be entirely excluded.

Frailty was estimated using BRASS, a discharge-planning screening tool rather than a HF-specific validated frailty instrument; consequently, some misclassification is possible, and replication using HF-validated frailty measures is warranted. From a methodological perspective, the LCA included a limited set of covariates (comorbidities and DRG weight), and the inclusion of additional clinical or care-related variables might have allowed the identification of more nuanced patient profiles. Future studies should therefore expand covariate selection and consider stratified analyses by HF subtypes, to test the robustness of the observed associations. Given the moderate entropy observed in the selected model, some degree of misclassification between profiles cannot be excluded, and individual-level class assignment should therefore be interpreted with caution.

Finally, as LOS was the primary outcome, other relevant endpoints—such as mortality, readmissions, and post-discharge trajectories—were not modeled, as they fell outside the scope of the study objectives. Although mortality and discharge disposition were available in the dataset, they were not included as primary outcomes in the present analyses. Future research should assess whether joint frailty-nursing complexity profiles predict a broader range of outcomes and extend to community-based care settings, where frailty is strongly associated with emergency department visits, hospital readmissions, and mortality in patients with HF,[51,52] with nursing complexity potentially increasing vulnerability.[53] Moreover, given that frailty may be at least partially preventable or reversible,[50] further studies should examine whether nursing practice may play a role in mitigating frailty-related vulnerability, including the effectiveness of nursing interventions in modifying patient trajectories and outcomes.

Conclusion

Frailty and nursing complexity were prevalent in hospitalized HF patients and showed weak but consistent associations with LOS. Two probabilistic admission profiles were identified, and the high frailty/high nursing complexity profile remained associated with prolonged LOS after adjustment for major clinical covariates. Early joint assessment of frailty-related vulnerability and nursing complexity at hospital admission may support early risk stratification and inform care planning and discharge management in patients with HF. Further prospective research should validate these findings using HF-specific frailty instruments and outcomes beyond LOS.

Ethical considerations

Ethical approval for this study was obtained by the Catholic University of the Sacred Heart (Prot. 0012,915/24, approved on 16th May 2024).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Antonello Cocchieri: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Fabio D'Agostino:** Writing – review & editing, Software. **Mario Cesare Nurchis:** Writing – review & editing, Validation, Formal analysis. **Ilaria Erba:** Writing – review & editing. **Noemi Giannetta:** Writing – review & editing. **Manuele Cesare:** Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.gerinurse.2026.103986.

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