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ORIGINAL RESEARCH

Rehospitalisation Patterns in Very Old Adults with Heart Failure Managed Within an Integrated Cardiogeriatric Post-Discharge Care Pathway: The REACT-HF Study

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Purpose: Very old adults with heart failure (HF) experience high rehospitalisation rates related to multimorbidity, functional vulnerability, and complex care transitions. Empirical evidence on factors associated with rehospitalisation in very old adults with HF managed within integrated post-discharge care pathways remains limited. This study aimed to describe rehospitalisation patterns and associated clinical markers in very old patients with HF managed within an integrated cardiogeriatric post-discharge pathway.

Patients and methods:: This retrospective single-centre cohort included patients aged ≥65 years hospitalised for acute HF and enrolled at discharge in an integrated cardiogeriatric pathway combining structured remote monitoring, rapid-access day-hospital services and coordinated outpatient follow-up (April 2023–August 2025). Analyses were restricted to patients who survived the early post-discharge period and had available 12-month follow-up data, in order to assess rehospitalisation status at predefined post-discharge time points. The primary outcome was unplanned HF rehospitalisation at 12 months; secondary outcomes included rehospitalisation at 3 and 6 months, predictors of rehospitalisation and hospital length of stay. Exploratory multivariable logistic regression analyses were performed.

Results: Among 255 very old patients with available 12-month follow-up data (median age 87 years), rehospitalisation rates were 9.8% at 3 months, 16.1% at 6 months and 24.7% at 12 months. Higher loop diuretic dose was associated with rehospitalisation at 3 months. At 6 months, moderate-to-severe mitral regurgitation, higher diuretic dose and absolute iron deficiency were independently associated with rehospitalisation. At 12 months, moderate-to-severe mitral regurgitation, iron deficiency and chronic obstructive pulmonary disease were independently associated. These findings apply to patients who survived the early post-discharge period and had sufficient follow-up data, rather than to an unselected acute HF population.

Conclusion: In very old patients with HF and available longitudinal follow-up, higher loop diuretic dose, iron deficiency, moderate-to-severe mitral regurgitation, and COPD were associated with rehospitalisation status at predefined time horizons. These exploratory findings suggest that routinely available clinical markers may help support risk-stratified follow-up in advanced-age HF populations.

Keywords: heart failure, older adults, integrated care, rehospitalisation

Introduction

Heart failure (HF) affects more than 64 million people worldwide and remains a leading cause of hospitalization in older adults.[1] Its prevalence increases markedly with age, exceeding 10% in individuals ≥80 years.[2] Older patients frequently present with multimorbidity, polypharmacy, cognitive impairment, functional dependence, and other geriatric vulnerabilities that complicate management and worsen outcomes.[3–6]

Transitions of care represent a particularly vulnerable period: nearly one in four older adults is readmitted within 30 days and more than half within one year.[7] These rehospitalisations often reflect system-level gaps in care delivery,

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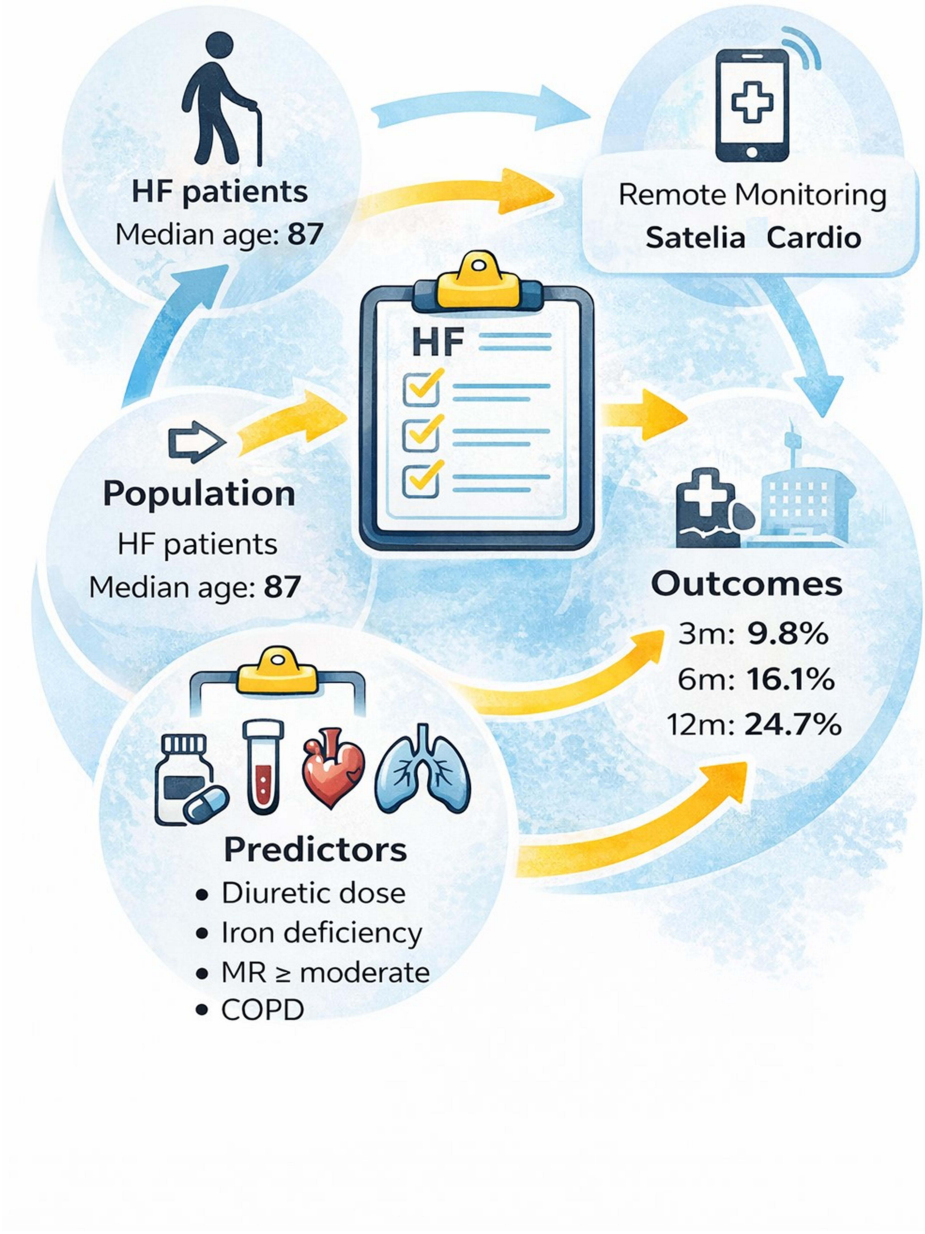
Graphical Abstract



including delayed symptom recognition, limited access to specialized reassessment, insufficient coordination between hospital and community teams, and underuse of intermediate care structures, especially in very old and dependent patients. Rehospitalisation after HF discharge is associated with functional decline, loss of independence, repeated exposure to hospital-related complications, and high healthcare utilisation in older adults. Identifying factors associated with rehospitalisation is therefore essential to better target post-discharge follow-up strategies in this population.

Remote patient monitoring has emerged as a care-support tool whose effectiveness largely depends on its integration within structured and responsive care pathways. Large trials and meta-analyses have reported heterogeneous results, while real-world data suggest that older adults with multimorbidity, functional limitations, or caregiver dependence—who face major barriers to self-management—may derive particular benefit when monitoring is embedded in coordinated

care models.[8] In France, the Remote Telemonitoring Program (RPM) Satelia® Cardio provides a structured digital follow-up integrated into routine HF pathways. High patient satisfaction has been reported, and the TELESAT-HF study demonstrated improved care coordination with reductions in mortality and emergency hospitalizations.[9]

Despite these advances, evidence specifically addressing very old, multimorbid cardiogeriatric patients remains limited, particularly regarding rehospitalisation patterns and predictors of outcomes. The REACT-HF study was therefore designed to evaluate rehospitalisation outcomes in very old patients enrolled in the RPM after acute HF hospitalization, focusing on care-relevant predictors, length of stay, and admission pathways within an integrated cardiogeriatric care delivery model, rather than on telemonitoring efficacy as a standalone intervention.

This study was conceived from a geriatric care perspective, focusing on care transitions, vulnerability, and organizational determinants of outcomes in very old patients with HF, rather than on the efficacy of HF therapies. The primary objective of the REACT-HF study was to evaluate unplanned rehospitalisation for HF within 12 months after index discharge in very old patients managed within an integrated cardiogeriatric post-discharge pathway. Secondary objectives were to describe rehospitalisation at 3 and 6 months, baseline patient characteristics, predictors of rehospitalisation at each time horizon, and hospital length of stay before and after RPM enrolment. We hypothesised that routinely available clinical markers of disease severity, congestion, valvular disease, and multimorbidity would be associated with rehospitalisation status during follow-up.

Methods

Study Design

This real-world, retrospective, observational, single-centre cohort study was conducted in a cardiogeriatric department of a tertiary hospital in the Greater Paris area, France, between 28 April 2023 and 31 August 2025. Consecutive very old patients were enrolled in an integrated cardiogeriatric post-discharge care pathway combining structured remote monitoring, rapid-access day-hospital services, and coordinated outpatient follow-up. The unit comprises 25 geriatric medicine beds dedicated to the management of very old patients with acute and chronic HF, integrating cardiology and geriatric expertise. It is the first geriatric department in France to implement a structured pathway combining outpatient follow-up, remote monitoring, titration and diuretic day-hospital care, intravenous iron therapy, and therapeutic patient education.

Within this integrated pathway, follow-up was supported by a web-based remote monitoring medical device designed to facilitate post-discharge surveillance and early clinical reassessment. All patients received an initial phone call within 48 hours of enrolment. According to protocol, patients or caregivers received SMS notifications once or twice weekly, with optional daily completion, linking to a web-based questionnaire assessing early signs of HF decompensation (dyspnoea, weight gain, oedema, fatigue). Worsening symptoms or significant weight gain automatically triggered an alert to the patient's cardiologist, enabling timely intervention. The system was accessible from any device without additional software or sensors. Limited digital literacy did not constitute a barrier, as nurses assisted patients by phone when needed. The RPM functioned exclusively as a coordination and alert-triggering tool within the care pathway and did not define clinical decision-making, therapeutic strategies, or outcome assessment.

Description of the Cardiogeriatric Care Pathway

The cardiogeriatric post-discharge care pathway aimed to optimize transitions between inpatient care, ambulatory management, and community follow-up in very old patients with HF. After acute hospitalization, patients were discharged into a structured pathway combining early post-discharge reassessment, coordinated outpatient follow-up, and rapid-access day-hospital services.

The pathway included non-programmed day-hospital admissions for clinical reassessment, intravenous diuretics, iron repletion, and medication titration, enabling early intervention without full rehospitalisation. Care was coordinated by a dedicated cardiogeriatric team integrating cardiology and geriatric expertise, ensuring continuity across settings.

This organization sought to reduce unnecessary prolonged hospital stays, support early discharge when appropriate, and allow flexible care escalation based on patient vulnerability and clinical trajectory.

Objectives

The study objectives were predefined as described in the Introduction. Briefly, the primary objective was to evaluate unplanned rehospitalisation for HF within 12 months after index discharge. Secondary objectives were to assess rehospitalisation at 3 and 6 months, describe baseline characteristics, identify predictors of rehospitalisation at each time horizon, and compare hospital LOS before and after RPM enrolment.

Study Population

Eligible participants were adults aged ≥65 years hospitalized for acute HF in a cardiogeriatric department and enrolled in the remote monitoring programme at discharge. For the present analysis, only patients with sufficient follow-up data to assess rehospitalisation status up to 12 months were included. This analytic strategy was chosen to allow consistent assessment at predefined post-discharge time horizons, but it excluded patients with early death or insufficient follow-up data, thereby introducing survivor selection bias; early mortality should be considered a major competing outcome in this very old population.

No formal a priori sample size calculation was performed because this was a retrospective real-world cohort study based on all consecutive eligible patients managed during the study period. The available sample therefore reflected routine clinical practice rather than a pre-specified powered recruitment target. Given the limited number of rehospitalisation events relative to the number of candidate predictors, multivariable analyses were considered exploratory and hypothesis-generating.

Data Collection

Data were retrospectively extracted from electronic medical records and routinely used in the clinical medical device. All baseline variables were collected at the time of index discharge and grouped into three broad categories: sociodemographic and geriatric characteristics, clinical characteristics, and covariates relevant to HF severity, biology, and treatment.

- Sociodemographic and geriatric characteristics: age, sex, Activities of Daily Living (ADL) score, Charlson Comorbidity Index, nutritional status, body mass index (BMI), albumin, obesity, depressive symptoms, cognitive impairment.
- Clinical characteristics: history or active cancer, chronic obstructive pulmonary disease (COPD), chronic kidney disease (CKD) stage, hypertension, dyslipidaemia, diabetes, stroke, peripheral artery disease (PAD), atrial fibrillation/flutter, amyloidosis, pacemaker, valvular disease, coronary artery disease, left ventricular ejection fraction (LVEF) category.
- Biological and therapeutic covariates: haemoglobin, anaemia status, iron status, ferritin, transferrin saturation, NT-proBNP, loop diuretic type and dose, ACEi/ARB, ARNi, beta-blockers, mineralocorticoid receptor antagonists (MRAs), SGLT2 inhibitors, anticoagulants, antiplatelet therapies.
- Outcomes: rehospitalisation for HF at 3, 6, and 12 months, and LOS before and after RPM enrolment.

Outcomes

The primary outcome was unplanned rehospitalisation for HF at 12 months after index discharge. Secondary outcomes were unplanned HF rehospitalisation at 3 and 6 months, and hospital LOS before and after RPM enrolment. Baseline patient characteristics were treated as candidate predictors (correlates) of rehospitalisation at each predefined time horizon rather than as study outcomes.

Statistical Analysis

The association between baseline characteristics and rehospitalisation for HF was evaluated at 3, 6, and 12 months. Rehospitalisation was treated as a binary outcome at each time horizon. Accordingly, the analyses were designed to explore associations with rehospitalisation status at fixed time points rather than to estimate absolute rehospitalisation

risk in the overall acute HF population. Separate logistic regression models were therefore used for each predefined time horizon because the study objective was not to model within-patient longitudinal change over repeated measurements, but to examine associations between discharge variables and rehospitalisation status at distinct clinically relevant post-discharge time points. In this context, generalized estimating equations or mixed-effects models were not retained, as the analysis was not designed to estimate subject-specific longitudinal trajectories or repeated-measure effects over time. All sociodemographic, clinical, biological, imaging, and therapeutic variables collected at discharge were considered as potential predictors. After data cleaning and recoding, variables were classified as continuous, ordinal, or binary. Continuous variables were summarized as means with standard deviation or medians with interquartile range, and categorical variables as counts and percentages. No imputation was performed for missing data.

Univariate comparisons between rehospitalised and non-rehospitalised patients were performed using Welch's *t*-test or Mann–Whitney *U*-test for continuous variables, and χ^2 or Fisher's exact test for categorical variables. Variables with $p < 0.05$ were retained as candidates for multivariable analysis at this exploratory stage. All variables associated with rehospitalisation in univariate analyses ($p < 0.05$) were considered as candidates, after which a restricted set of clinically meaningful predictors, predefined based on their established prognostic relevance in very old HF patients, was retained for inclusion in the multivariable models.

Multivariable logistic regression models were constructed separately for each time horizon (3, 6, and 12 months) in order to explore associations with rehospitalisation status at fixed post-discharge time points. Covariate selection followed a pragmatic and clinically driven approach, combining variables with established prognostic relevance in very old HF populations (age, sex, Charlson Index, moderate-or-greater mitral regurgitation, absolute iron deficiency, CKD stage, NT-proBNP) and variables associated with rehospitalisation in univariate analyses ($p < 0.05$). Discharge loop diuretic dose was retained given its recognised role as a marker of congestion and disease severity. Because the number of rehospitalisation events was limited relative to the number of candidate predictors, the events-per-variable ratio was low, increasing the risk of overfitting and coefficient instability. Given the low EPV, model stability could not be formally assessed through additional sensitivity analyses, and results should therefore be interpreted with caution. Model assumptions and performance were assessed using ROC analysis, variance inflation factors for collinearity, and checks for logit-linearity. Accordingly, all multivariable analyses were considered exploratory and hypothesis-generating rather than confirmatory.

Competing-risk analyses were not performed because the present study was not designed to estimate cumulative rehospitalisation risk in the full post-discharge population, and the limited number of events would have made such models insufficiently robust in this dataset.

Ethical Considerations

This study was classified as research not involving the human person (RNIPH) under French law. It was approved by the Internal Ethics Committee of the Groupement Hospitalier de l'Institut Catholique de Lille (GHICL) (Ref: RNIPH-2025-37).

All procedures complied with the Declaration of Helsinki and the General Data Protection Regulation (EU 2016/679). Given the retrospective and non-interventional nature of the study, no individual consent was required, but all patients were informed that their anonymized data could be used for research purposes.

Results

A total of 991 patients aged >65 years were enrolled in the remote monitoring program at the Department of Cardiogeriatrics between April 2023 and August 2025. Among them, 736 were excluded from the present analysis because 12-month rehospitalisation status could not be consistently assessed. Reasons for exclusion included death during follow-up (n = 172), insufficient or inconsistent follow-up (n = 85), unsubscription or discontinuation of the monitoring programme (n = 185), availability of <12 months of clinical data (n = 277), and other reasons (n = 17). No patient was lost to follow-up.

The final analytical cohort consisted of 255 patients with sufficient follow-up data to ascertain rehospitalisation status up to 12 months. The flow of patient selection is presented in Figure 1.

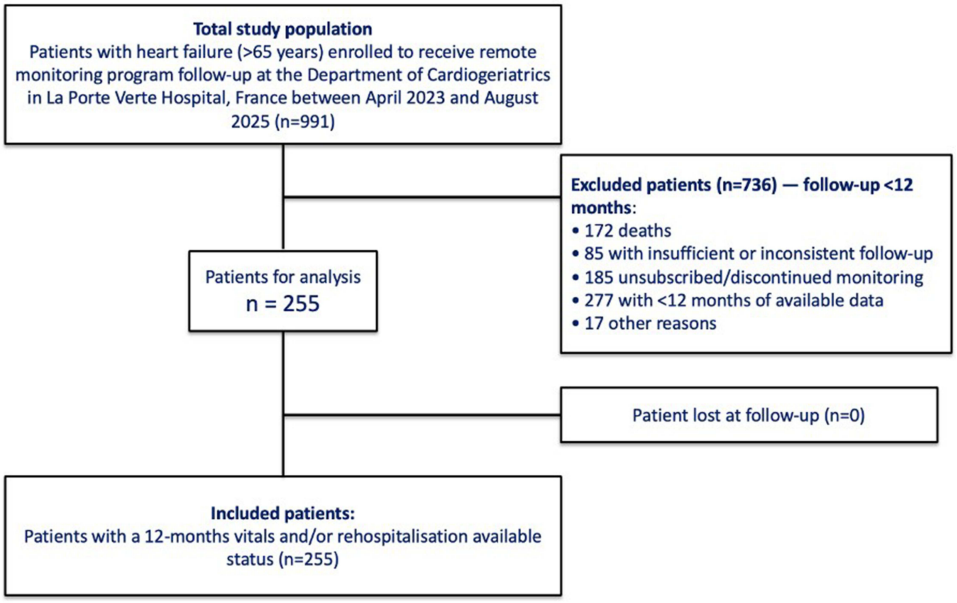


Figure 1 Flow chart of the study population and selection process (n=991).

Baseline Characteristics

A total of 255 patients were included in the analysis. The median age was 87 years [IQR 81–91], and 46.3% were women. The population exhibited a high burden of multimorbidity, with a median Charlson Index of 8 [6–9], and frequent hypertension (68.1%), dyslipidemia (60.0%), diabetes (32.9%), atrial fibrillation/flutter (72.5%), and chronic kidney disease, as more than half (52.9%) presented an eGFR <45 mL/min/1.73 m^2 at discharge. Markers of geriatric vulnerability included a median ADL score of 5.5 [5–6], malnutrition risk in 49.0% of patients, and severe malnutrition in 31.8%. Albumin levels were low (median 32 g/L [28.5–35.5]), and absolute (26.1%) and functional (28.6%) iron deficiency were common.

On cardiac evaluation, 27.2% had reduced LVEF (≤40%) and 11.2% had moderate-or-greater mitral regurgitation. The median NT-proBNP level at discharge was 2000 pg/mL [978–3707.25]. Medical therapy reflected contemporary HF care, with 92.2% receiving a loop diuretic, 73.7% a beta-blocker, 47.8% an ACE inhibitor or ARB, 15.7% an MRA, and 87.8% an SGLT2 inhibitor. Baseline characteristics and univariate associations with 3-, 6-, and 12-months rehospitalisation are shown in Table 1. Additional baseline variables and alternative categorizations are provided in Supplementary Table S1.

Patients who were rehospitalised tended to present higher levels of functional dependence and nutritional vulnerability at baseline, although these differences did not reach statistical significance.

Rehospitalisation Rates

Rehospitalisations occurred in 9.8% of patients at 3 months, 16.1% at 6 months, and 24.7% at 12 months. There were no missing data for the primary outcome. In univariate analyses, rehospitalised patients tended to present lower ferritin levels, a higher prevalence of moderate-or-greater mitral regurgitation and COPD, higher rates of absolute iron deficiency, and higher loop diuretic doses at discharge. Although these associations varied across time points, several trends remained consistent during follow-up.

All reported adjusted odds ratios derive from multivariable models including the predefined covariate set described in the Statistical Analysis section.

Predictors of 3-Month Rehospitalisation

In the adjusted model (Table 2), only the discharge loop diuretic dose was statistically significantly associated with early rehospitalisation (adjusted OR 1.002, 95% CI 1.000–1.004; p = 0.033). Moderate-or-greater mitral regurgitation (adjusted

Table 1 Baseline Characteristics and Univariate Associations with Rehospitalisation at 3, 6 and 12 Months

Variable	Overall	Rehospitalisation at 3 Months, N = 25 (9.8%)	p-value	Rehospitalisation at 6 Months, N = 41 (16.1%)	p-value	Rehospitalisation at 12 Months, N = 63 (24.7%)	p-value
Demographics & functional status							
Age, median [IQR]	87.00 [81.00–91.00]	88.00 [84.00–91.00]	0.604	88.00 [84.00–92.00]	0.390	87.00 [82.00–91.00]	0.874
Sex	118 (46.3%)	9 (36.0%)	0.382	17 (41.5%)	0.615	26 (41.3%)	0.440
ADL, median [IQR]	5.50 [5.00–6.00]	5.50 [5.00–6.00]	0.598	5.50 [5.00–6.00]	0.273	5.50 [5.25–6.00]	0.716
Charlson Score Index, median [IQR]	8.00 [6.00–9.00]	8.00 [6.00–9.00]	0.744	8.00 ± 1.84	1.000	8.00 [7.00–10.00]	0.202
Comorbidities							
Depression	52 (20.4%)	9 (36.0%)	0.075	14 (34.1%)	0.030	15 (23.8%)	0.551
Hypertension	173 (68.1%)	19 (76.0%)	0.506	30 (73.2%)	0.564	48 (76.2%)	0.152
Diabetes	84 (32.9%)	6 (24.0%)	0.437	11 (26.8%)	0.467	23 (36.5%)	0.589
Atrial fibrillation/flutter	185 (72.5%)	18 (72.0%)	1.000	31 (75.6%)	0.773	46 (73.0%)	1.000
eGFR<45 mL/min/1.73 m^2	135 (52.9%)	17 (68.0%)	0.168	25 (61.0%)	0.340	39 (61.9%)	0.134
COPD	23 (9.0%)	3 (12.0%)	0.480	4 (9.8%)	0.772	11 (17.5%)	0.015
HF severity and echocardiography							
LVEF	–	–	–	–	–	–	–
Reduced (≤40%)	68 (27.2%)	6 (24.0%)	0.023	10 (24.4%)	0.111	18 (28.6%)	0.745
Mildly reduced (41–49%)	35 (14.0%)	8 (32.0%)	–	10 (24.4%)	–	10 (15.9%)	–
Preserved (≥50%)	147 (58.8%)	11 (44.0%)	–	21 (51.2%)	–	34 (54.0%)	–
Mitral regurgitation, at least moderate	28 (11.2%)	6 (24.0%)	0.070	10 (24.4%)	0.008	13 (20.6%)	0.009
Absolute iron deficiency	63 (26.1%)	9 (36.0%)	0.345	17 (41.5%)	0.024	27 (42.9%)	<0.001
Laboratory parameters							
NT-proBNP at discharge (pg/mL), median [IQR]	2000.50 [978.00–3707.25]	2486.00 [1201.00–4902.00]	0.313	2459.00 [1205.00–4751.00]	0.076	2392.00 [1281.00–4626.50]	0.033
Ferritin, median [IQR]	210.00 [94.00–381.00]	147.00 [66.00–251.00]	0.030	129.00 [68.00–211.00]	0.004	124.00 [71.00–239.00]	<0.001
Treatments at discharge and follow up							
Loop diuretic	235 (92.2%)	23 (92.0%)	1.000	39 (95.1%)	0.750	61 (96.8%)	0.174

(*Continued*)

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Table 1 (Continued).

Variable	Overall	Rehospitalisation at 3 Months, N = 25 (9.8%)	p-value	Rehospitalisation at 6 Months, N = 41 (16.1%)	p-value	Rehospitalisation at 12 Months, N = 63 (24.7%)	p-value
Discharge loop diuretic dose, median [IQR]	80.00 [40.00–120.00]	125.00 [80.00–125.00]	<0.001	120.00 [80.00–125.00]	<0.001	80.00 [80.00–125.00]	<0.001
ACEi/ARB	122 (47.8%)	13 (52.0%)	0.820	23 (56.1%)	0.325	33 (52.4%)	0.493
ARNi	50 (19.6%)	3 (12.0%)	0.430	4 (9.8%)	0.090	10 (15.9%)	0.498
Beta-blocker	188 (73.7%)	16 (64.0%)	0.355	28 (68.3%)	0.503	49 (77.8%)	0.498
MRA	40 (15.7%)	4 (16.0%)	1.000	7 (17.1%)	0.974	12 (19.0%)	0.518
ISGLT2	224 (87.8%)	22 (88.0%)	1.000	36 (87.8%)	1.000	55 (87.3%)	1.000

Notes: Continuous variables are presented as median [interquartile range] or mean ± standard deviation, and categorical variables as number (%). Comparisons between patients with and without rehospitalisation at 3, 6, and 12 months were performed using Mann–Whitney U or χ^2/Fisher's exact tests, as appropriate.

Abbreviations: ADL, Activities of Daily Living; ARB, Angiotensin Receptor Blocker; ACEi, Angiotensin-Converting Enzyme Inhibitor; ARNi, Angiotensin Receptor–Neprilysin Inhibitor; COPD, Chronic Obstructive Pulmonary Disease; CKD, Chronic Kidney Disease; eGFR, Estimated Glomerular Filtration Rate; HF, Heart Failure; IQR, Interquartile Range; LVEF, Left Ventricular Ejection Fraction; MR, Mitral Regurgitation; MRA, Mineralocorticoid Receptor Antagonist; NT-proBNP, N-terminal pro–B-type Natriuretic Peptide; SGLT2i, Sodium–Glucose Cotransporter-2 Inhibitor.

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Table 2 Multivariate Predictors of 3-Months Rehospitalisation

Variable	Adjusted OR (95% CI)	p-value
Age, median [IQR]	1.011 (0.940–1.087)	0.771
Sex	0.727 (0.291–1.813)	0.494
ADL, median [IQR]	0.849 (0.549–1.313)	0.461
Charlson Score Index, median [IQR]	0.988 (0.812–1.203)	0.906
COPD	1.370 (0.353–5.309)	0.649
eGFR<45 mL/min/1.73 m^2	2.470 (0.903–6.752)	0.078
Hypertension	1.399 (0.522–3.749)	0.505
Mitral regurgitation, at least moderate	2.715 (0.957–7.700)	0.060
LVEF		
Reduced (≤40%)	Ref	Ref
Mildly reduced (41–49%)	2.650 (0.797–8.806)	0.071
Preserved (≥50%)	0.732 (0.246–2.179)	0.071
Ferritin, median [IQR]	0.997 (0.993–1.000)	0.077
Absolute iron deficiency	1.371 (0.547–3.437)	0.501
NT-proBNP at discharge (pg/mL), median	1.000 (1.000–1.000)	0.456
Discharge loop diuretic dose, median [IQR]	1.002 (1.000–1.004)	0.033

Notes: Multivariable logistic regression was performed to identify independent predictors of 3-months rehospitalisation. Multivariable logistic regression models included clinically relevant covariates based on prior evidence and univariate associations. Given the limited event numbers, these fully adjusted models should be interpreted as exploratory. Odds ratios (OR) with their 95% confidence intervals (CI) are reported. Reference category for LVEF is reduced LVEF (≤40%). Continuous variables were modeled per one-unit increase. A p-value <0.05 was considered statistically significant.

Abbreviations: ADL, Activities of Daily Living; CI, Confidence Interval; COPD, Chronic Obstructive Pulmonary Disease; eGFR, Estimated Glomerular Filtration Rate; HF, Heart Failure; IQR, Interquartile Range; LVEF, Left Ventricular Ejection Fraction; MR, Mitral Regurgitation; NT-proBNP, N-terminal pro-B-type Natriuretic Peptide; OR, Odds Ratio.

OR 2.72, 95% CI 0.96–7.70; p = 0.060) and chronic kidney disease with eGFR <45 mL/min/1.73 m^2 (adjusted OR 2.47, 95% CI 0.90–6.75; p = 0.078) showed borderline associations. No other demographic, geriatric, clinical, biological, or imaging variable was statistically significantly associated with 3-month rehospitalisation in the adjusted model.

Predictors of 6-Month Rehospitalisation

At 6 months, moderate-or-greater mitral regurgitation was statistically significantly associated with rehospitalisation in the adjusted model (adjusted OR 3.141, 95% CI 1.287–7.667; p = 0.012). Absolute iron deficiency was also statistically significantly associated with rehospitalisation (adjusted OR 2.164, 95% CI 1.021–4.586; p = 0.044), and discharge loop diuretic dose remained statistically significantly associated (adjusted OR 1.002, 95% CI 1.000–1.004; p = 0.025). No statistically significant associations were observed for age, sex, ADL, Charlson index, comorbidities, CKD stage, NT-proBNP, or LVEF. Results are shown in Table 3.

Predictors of 12-Month Rehospitalisation

At 12 months, moderate-or-greater mitral regurgitation (adjusted OR 3.189, 95% CI 1.344–7.564; p = 0.008), absolute iron deficiency (adjusted OR 2.983, 95% CI 1.529–5.819; p = 0.001), and COPD (adjusted OR 2.682, 95% CI 1.031–6.975; p = 0.043) were statistically significantly associated with rehospitalisation in the adjusted model. The

Table 3 Multivariate Predictors of 6-Months Rehospitalisation

Variable	Adjusted OR (95% CI)	p-value
Age, median [IQR]	1.018 (0.959–1.080)	0.558
Sex	1.055 (0.501–2.223)	0.887
ADL, median [IQR]	0.926 (0.629–1.365)	0.698
Charlson Score Index, median [IQR]	0.994 (0.847–1.166)	0.939
COPD	0.946 (0.284–3.152)	0.928
eGFR<45 mL/min/1.73 m^2	1.694 (0.764–3.757)	0.194
Hypertension	1.137 (0.515–2.508)	0.751
Mitral regurgitation, at least moderate	3.141 (1.287–7.667)	0.012
LVEF		
Reduced (≤40%)	Ref	Ref
Mildly reduced (41–49%)	1.899 (0.662–5.449)	0.341
Preserved (≥50%)	0.944 (0.393–2.266)	0.341
Ferritin, median [IQR]	0.999 (0.998–1.001)	0.493
Absolute iron deficiency	2.164 (1.021–4.586)	0.044
NT-proBNP at discharge (pg/mL), median [IQR]	1.000 (1.000–1.000)	0.295
Discharge loop diuretic dose, median [IQR]	1.002 (1.000–1.004)	0.025

Notes: Multivariable logistic regression was performed to identify independent predictors of 6-months rehospitalisation. Multivariable logistic regression models included clinically relevant covariates based on prior evidence and univariate associations. Given the limited event numbers, these fully adjusted models should be interpreted as exploratory. Odds ratios (OR) with their 95% confidence intervals (CI) are reported. Reference category for LVEF is reduced LVEF (≤40%). Continuous variables were modeled per one-unit increase. A p-value <0.05 was considered statistically significant.

Abbreviations: ADL, Activities of Daily Living; CI, Confidence Interval; COPD, Chronic Obstructive Pulmonary Disease; eGFR, Estimated Glomerular Filtration Rate; HF, Heart Failure; IQR, Interquartile Range; LVEF, Left Ventricular Ejection Fraction; MR, Mitral Regurgitation; NT-proBNP, N-terminal pro-B-type Natriuretic Peptide; OR, Odds Ratio.

discharge loop diuretic dose showed a non-significant trend (adjusted OR 1.002, 95% CI 1.000–1.003; p = 0.095). No other variable demonstrated a statistically significant association in the fully adjusted model. Full results are provided in Table 4. The adjusted predictors of 12-month rehospitalisation for HF are summarized in Figure 2.

Comparison of Hospital Length of Stay Before and After the RPM Enrolment

Hospital LOS was compared before and after enrolment in the RPM at 3, 6, and 12 months (Table 5).

At 3 months, LOS increased from 7.0 days [6.0–9.0] to 8.0 days [6.0–14.0], without reaching statistical significance (p = 0.065).

At 6 months, LOS increased significantly from 7.0 days [6.0–9.0] to 8.0 days [7.0–14.0] (p = 0.002).

At 12 months, LOS was also significantly higher after enrolment, rising from 7.0 days [6.0–9.0] to 8.0 days [6.0–12.75] (p = 0.014).

Overall, LOS was higher after enrolment, with significant differences at 6 and 12 months.

Discussion

This real-world cardiogeriatric cohort provides insight into rehospitalisation patterns among very old, multimorbid patients with marked functional and clinical vulnerability managed within a structured post-discharge pathway. With

Table 4 Multivariate Predictors of 12-Months Rehospitalisation

Variable	Adjusted OR (95% CI)	p-value
Age, median [IQR]	0.973 (0.925–1.024)	0.297
Sex	1.006 (0.525–1.928)	0.985
ADL, median [IQR]	1.128 (0.773–1.645)	0.532
Charlson Score Index, median [IQR]	1.108 (0.967–1.269)	0.139
COPD	2.682 (1.031–6.975)	0.043
eGFR<45 mL/min/1.73 m^2	1.649 (0.822–3.310)	0.159
Hypertension	1.505 (0.741–3.054)	0.258
Mitral regurgitation, at least moderate	3.189 (1.344–7.564)	0.008
LVEF		
Reduced (≤40%)	Ref	Ref
Mildly reduced (41–49%)	0.872 (0.320–2.374)	0.914
Preserved (≥50%)	0.856 (0.411–1.781)	0.914
Ferritin, median [IQR]	0.999 (0.998–1.001)	0.334
Absolute iron deficiency	2.983 (1.529–5.819)	0.001
NT-proBNP at discharge (pg/mL), median [IQR]	1.000 (1.000–1.000)	0.424
Discharge loop diuretic dose, median [IQR]	1.002 (1.000–1.003)	0.095

Notes: Multivariable logistic regression was performed to identify independent predictors of 12-months rehospitalisation. Multivariable logistic regression models included clinically relevant covariates based on prior evidence and univariate associations. Given the limited event numbers, these fully adjusted models should be interpreted as exploratory. Odds ratios (OR) with their 95% confidence intervals (CI) are reported. Reference category for LVEF is reduced LVEF (≤40%). Continuous variables were modeled per one-unit increase. A p-value <0.05 was considered statistically significant.

Abbreviations: ADL, Activities of Daily Living; CI, Confidence Interval; COPD, Chronic Obstructive Pulmonary Disease; eGFR, Estimated Glomerular Filtration Rate; HF, Heart Failure; IQR, Interquartile Range; LVEF, Left Ventricular Ejection Fraction; MR, Mitral Regurgitation; NT-proBNP, N-terminal pro-B-type Natriuretic Peptide; OR, Odds Ratio.

a median age of 87 years, it represents one of the oldest HF populations reported in studies incorporating remote monitoring. Outcomes are described within an integrated cardiogeriatric care model in which telemonitoring constitutes one component of a broader organizational framework, including coordinated follow-up and rapid-access day-hospital support. Descriptively, rehospitalised patients appeared to have greater functional and nutritional vulnerability at baseline, although no independent association was identified in multivariable analyses.

Among patients with sufficient follow-up data who survived the early post-discharge period, the 12-month rehospitalisation rate (24.7%) falls within the range of rates reported in large HF registries, although direct comparison remains limited by differences in population characteristics and survivor selection.[10,11] Accordingly, these descriptive comparisons should not be interpreted as evidence of reduced rehospitalisation risk or pathway effectiveness. These findings should be interpreted cautiously, as the analytical cohort was composed of very old patients who survived the early post-discharge period. Early mortality represents a major competing outcome in this population and may have limited the inclusion of the most vulnerable individuals. Accordingly, the reported associations reflect rehospitalisation among very old patients who survived the early post-discharge period and should not be interpreted as estimates of absolute rehospitalisation risk in the full population of hospitalized older adults with HF. Observed rehospitalisation rates should

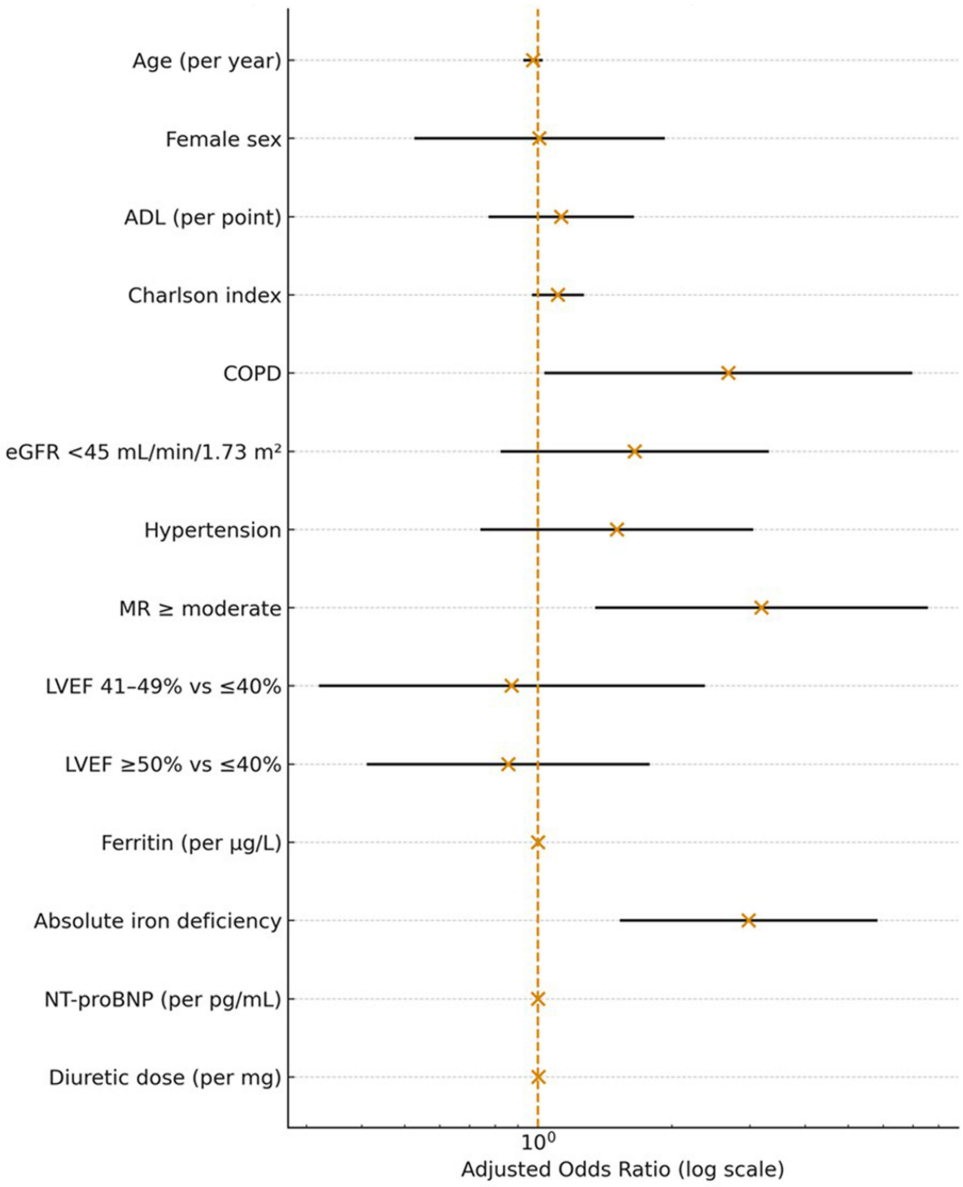

Figure 2 Adjusted predictors of 12-months rehospitalisation for heart failure in the REACT-HF cohort.
Notes: Forest plot presenting adjusted odds ratios (ORs) with 95% confidence intervals for variables included in the multivariable logistic regression model. A logarithmic scale is used for the OR axis, with a vertical reference line at 1. COPD, moderate-or-greater mitral regurgitation, and absolute iron deficiency were independently associated with 12-months rehospitalisation, while other variables did not reach statistical significance.

not be interpreted as evidence of pathway effectiveness, given the survivor-selected analytic cohort, the observational design, and the absence of a control group.

Although functional status, nutritional vulnerability and cognitive impairment are clinically central in geriatric HF care, these variables were not retained in final multivariable models.[12–14] This likely reflects limited statistical power and the low number of outcome events rather than a lack of clinical relevance. The observed rehospitalisation patterns may have been influenced by multiple clinical and organisational factors; however, no causal inference can be drawn from the present study. Baseline geriatric assessment nonetheless provided essential contextual information on patient vulnerability and care complexity, even when not independently associated with rehospitalisation in exploratory models.

Table 5 Comparison of Hospital Length of Stay Before and After Enrolment in the Telemonitoring Program at 3, 6, and 12 Months

Horizon	LOS Before RPM, Median [IQR]	LOS After RPM, Median [IQR]	p-value	95% CI
3 months	7.00 [6.00–9.00]	8.00 [6.00–14.00]	0.065	1.60–31.60
6 months	7.00 [6.00–9.00]	8.00 [7.00–14.00]	0.002	2.00–24.00
12 months	7.00 [6.00–9.00]	8.00 [6.00–12.75]	0.014	2.00–26.43

Notes: Values are presented as median [interquartile range]. Comparisons between hospital length of stay before and after enrolment in the telemonitoring program were performed using the Wilcoxon paired-sample test. Ninety-five percent confidence intervals (95% CI) correspond to the difference in LOS between periods. A p-value <0.05 was considered statistically significant.
Abbreviations: LOS, Length of Stay; RPM, Remote Patient Telemonitoring.

Loop Diuretic Dose and Early Rehospitalisation

Higher loop diuretic dose at discharge was associated with 3- and 6-months rehospitalisation, consistent with prior studies linking elevated diuretic requirements to congestion severity and clinical instability.[15,16] Although not causal, discharge dose may serve as a pragmatic risk marker in older telemonitored patients, likely reflecting disease severity rather than a causal effect. This finding is consistent with our hypothesis that discharge markers reflecting congestion burden and disease severity would be associated with subsequent rehospitalisation.

Iron Deficiency as a Predictor of Rehospitalisation

Absolute iron deficiency independently predicted rehospitalisation at 6 and 12 months, in line with the prognostic impact reported by Jankowska and von Haehling[17] and the benefits of IV iron therapy demonstrated in FAIR-HF, CONFIRM-HF, AFFIRM-AHF and IRONMAN.[18,19] Correction of iron deficiency may therefore be highly relevant in very old HF patients, although causality cannot be inferred. This also aligns with our hypothesis that routinely available biological markers associated with clinical vulnerability may help identify patients at higher rehospitalisation risk.

Valvular Regurgitation and COPD as Long-Term Risk Markers

Moderate-or-greater mitral regurgitation predicted 12-months rehospitalisation, consistent with findings from Grigioni and Rossi[20] and with insights from COAPT and MITRA-FR. COPD was also a long-term predictor, echoing prior evidence showing increased hospitalization risk and clinical complexity in HF–COPD overlap.[21,22] Its emergence at 12 months suggests progressive vulnerability beyond the early post-discharge period. Together, these findings support our hypothesis that structural cardiac disease and multimorbidity contribute to rehospitalisation risk in very old HF populations.

Remote Monitoring & Integrated Care

In the present study, telemonitoring was one component of a broader cardiogeriatric post-discharge model and was not evaluated as an isolated intervention. Accordingly, no causal inference can be made regarding the contribution of telemonitoring itself to the observed rehospitalisation patterns. The present findings should instead be interpreted within the context of an integrated care pathway in which remote monitoring served as a coordination and alerting tool.

Length of Stay

Hospital LOS increased modestly after enrolment, consistent with evidence showing longer stays in very old, clinically complex HF patients.[23,24] This likely reflects the cohort's advanced age (median 87 years) and high multimorbidity burden, factors known to prolong hospitalization independently of care pathways. Because this study was not designed to assess causal effects on LOS, these findings should be interpreted descriptively.[25,26]

Implications for Care Delivery and Pathway Design

These findings suggest that simple, routinely available discharge variables may help identify very old patients with HF who require closer post-discharge follow-up. In particular, higher loop diuretic dose may reflect persistent congestion burden, iron deficiency may identify biologically vulnerable patients who could warrant reassessment of iron status and treatment, and moderate-to-severe mitral regurgitation or COPD may help flag patients with greater long-term clinical complexity. From a care delivery perspective, these markers may help prioritise cardiogeriatric reassessment and closer surveillance after discharge. Because of the observational design, these implications should be interpreted cautiously and viewed as supportive of hypothesis generation rather than direct practice recommendations.

Strengths, Limitations, and Future Directions

A major strength of this study is its focus on a highly under-represented population of very old patients with HF and substantial multimorbidity and marked functional and clinical vulnerability, with detailed cardiogeriatric and echocardiographic characterisation rarely reported in remote monitoring studies.

Potential sources of bias included survivor selection related to the 12-month follow-up requirement, residual confounding inherent to the observational design, and model instability related to the low events-per-variable ratio.

Several limitations should be acknowledged. First, survivor selection related to the follow-up requirement is a major limitation of this study. Restricting the analysis to patients with sufficient follow-up data to assess rehospitalisation up to 12 months may have excluded individuals with early death or insufficient follow-up data, thereby limiting generalisability to survivors of the early post-hospital phase. Early mortality is a major competing outcome in very old HF populations and was not incorporated into the present analyses. Second, the retrospective single-centre design and absence of a control group preclude causal inference. Third, the modest number of rehospitalisation events relative to the number of predictors increases the risk of overfitting and limits the robustness of adjusted estimates; multivariable analyses should therefore be interpreted as exploratory and hypothesis-generating.[27]

Despite these limitations, this study identifies simple, routinely available clinical markers—loop diuretic dose, iron deficiency, mitral regurgitation and chronic obstructive pulmonary disease—associated with rehospitalisation in very old patients with HF. The findings should be interpreted within a care model in which remote monitoring was integrated into a structured cardiogeriatric pathway, although its specific contribution cannot be determined here. Future multicentre studies incorporating competing-risk methodologies and detailed evaluation of care processes are warranted to refine post-acute strategies in advanced-age HF populations.

Conclusion

In very old patients with HF followed within an integrated cardiogeriatric post-discharge pathway, higher loop diuretic dose, absolute iron deficiency, moderate-to-severe mitral regurgitation, and COPD were associated with rehospitalisation status at predefined time horizons. These variables may help support risk-stratified follow-up after discharge, but the findings should be interpreted cautiously given survivor selection, early mortality as a competing outcome, the observational design, and the limited number of outcome events.

Institutional Footnote

All institutional affiliations, including corporate appointments (NP Medical), are acknowledged as required.

Data Sharing Statement

The datasets used and/or analysed during the current study are available from the corresponding author (R.E.) on reasonable request. Due to patient privacy restrictions, data are not publicly available.

Ethical Approval and Consent to Participate

This study was classified as research not involving the human person (RNIPH) under French law. It was approved by the Internal Ethics Committee of the Groupement Hospitalier de l'Institut Catholique de Lille (GHICL) (Ref: RNIPH-2025-37).

All procedures complied with the Declaration of Helsinki and the General Data Protection Regulation (EU 2016/679). Given the retrospective and non-interventional nature of the study, no individual consent was required, but all patients were informed that their anonymized data could be used for research purposes.

Consent for Publication

The manuscript does not include any individual person's data in any form (images, videos, or identifiable details).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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