

**Table S1.** Missing data summary

| Variable                | No.<br>missing | %<br>missing | % missing<br>rule-out | % missing<br>gray zone | <i>P</i> * | Handling                           |
|-------------------------|----------------|--------------|-----------------------|------------------------|------------|------------------------------------|
| AF on ECG at admission  | 152            | 33.5         | 41.2                  | 25.9                   | .001       | Excluded from multivariable models |
| Systolic blood pressure | 70             | 15.4         | 21.6                  | 9.2                    | < .001     | Excluded from multivariable models |
| C-reactive protein      | 54             | 11.9         | 15.9                  | 7.9                    | .008       | Multiple imputation (MICE)         |
| Heart rate              | 52             | 11.5         | 16.8                  | 6.1                    | < .001     | Multiple imputation (MICE)         |
| Oxygen saturation       | 47             | 10.4         | 14.2                  | 6.6                    | .008       | Multiple imputation (MICE)         |
| Chest x-ray findings    |                |              |                       |                        |            |                                    |
| Interstitial edema      | 25             | 5.5          | 0                     | 11.0                   | < .001     | Excluded from multivariable models |
| Pleural effusion        | 25             | 5.5          | 0                     | 11.0                   | < .001     | Excluded from multivariable models |
| Cardiomegaly            | 25             | 5.5          | 0                     | 11.0                   | < .001     | Excluded from multivariable models |
| eGFR                    | 9              | 1.9          | 1.8                   | 2.1                    | .999       | Multiple imputation (MICE)         |
| Hemoglobin              | 2              | 0.4          | 0.9                   | 0                      | .247       | Multiple imputation (MICE)         |

AF, atrial fibrillation; ECG, electrocardiogram; eGFR, estimated glomerular filtration rate, MICE, multiple imputation by changed equations.

MICE with predictive mean matching (k = 5 nearest donors, 20 imputed datasets). Chest x-ray findings and atrial fibrillation on ECG were missing in patients who did not undergo the corresponding test during the index visit; as their absence reflects a test not performed rather than a missing measurement, multiple imputation was not considered appropriate, and these variables were excluded from multivariable models. *P*-values correspond to chi-square tests (Fisher exact test for eGFR and hemoglobin) comparing missing proportions between groups.

**Table S2.** Covariate balance before and after inverse probability of treatment weighting (IPTW)

| Variable                         | Rule-out,<br>mean/% | Gray zone,<br>mean/% | SMD<br>unweighted | SMD after IPTW |
|----------------------------------|---------------------|----------------------|-------------------|----------------|
| Age, y                           | 64.9                | 79.9                 | 1.202             | 0.212          |
| eGFR, mL/min/1.73 m <sup>2</sup> | 91.3                | 78.4                 | −0.368            | 0.089          |
| Atrial fibrillation, %           | 4.0                 | 20.6                 | 0.522             | 0.172          |
| Hemoglobin, g/dL                 | 13.5                | 12.5                 | −0.524            | −0.032         |
| Oxygen saturation, %             | 96.2                | 95.6                 | −0.130            | −0.051         |
| Hypertension, %                  | 57.5                | 72.4                 | 0.314             | −0.004         |
| Diabetes mellitus, %             | 25.7                | 33.3                 | 0.168             | −0.033         |
| COPD, %                          | 15.9                | 25.4                 | 0.236             | 0.109          |

COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate, IPTW, inverse probability of treatment weighting; SMD, standardized mean difference.

SMD absolute values shown. The sign indicates the direction of the difference (gray zone minus rule-out); the absolute magnitude is what determines balance, with values < .1 conventionally considered to indicate good balance. Weighted SMD calculated using stabilized inverse probability of treatment weights, truncated at the 1st/99th percentiles.

**Table S3.** Sensitivity analysis: hazard ratio for gray-zone NT-proBNP across alternative covariate adjustment strategies

| Model                                                                                                                  | All-cause mortality |          | First HF hospitalization |          |
|------------------------------------------------------------------------------------------------------------------------|---------------------|----------|--------------------------|----------|
|                                                                                                                        | HR (95%CI)          | <i>P</i> | sHR (95%CI)              | <i>P</i> |
| Unadjusted (univariate)                                                                                                | 8.36 (4.56-15.33)   | < .001   | 12.82 (5.13-32.01)       | < .001   |
| Data-driven (variables with <i>P</i> < .05* in univariate analysis)                                                    | 4.39 (2.27-8.47)    | < .001   | 7.22 (2.57-20.28)        | < .001   |
| Minimal clinical model (age, eGFR, atrial fibrillation, hemoglobin).                                                   | 4.67 (2.40-9.08)    | < .001   | 6.82 (2.44-19.09)        | < .001   |
| Extended clinical model (age, eGFR, atrial fibrillation, hemoglobin, oxygen saturation, hypertension, diabetes, COPD). | 4.59 (2.35-8.94)    | < .001   | 6.53 (2.38-17.89)        | < .001   |

CI, confidence interval; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; HR, hazard ratio; HF, heart failure; sHR, subdistribution hazard ratio.

\*A stricter univariate threshold (*P* < .010) was applied for the data-driven model of HF hospitalization, given the limited number of events and the resulting low events-per-variable ratio with the standard *P* < .05 threshold. The data-driven model included, for all-cause mortality: age, dyslipidemia, prior myocardial infarction, chest pain, rales, peripheral edema, hemoglobin, and oxygen saturation; and for HF hospitalization: age, hypertension, COPD, atrial fibrillation, progressive dyspnoea, rales, peripheral oedema, hemoglobin, and eGFR. All models were estimated using multiple imputation by chained equations (20 imputed datasets).

**Table S4.** Baseline characteristics according to hospital admission status

| Variable                                | Not admitted (n = 302) | Admitted (n = 152) | P      |
|-----------------------------------------|------------------------|--------------------|--------|
| <i>Age, y</i>                           | 71.6 ± 15.2            | 74.1 ± 13.0        | .082   |
| <i>Male sex</i>                         | 163 (54.0)             | 84 (55.3)          | .795   |
| <i>Gray zone group</i>                  | 129 (42.7)             | 99 (65.1)          | < .001 |
| <i>Medical history</i>                  |                        |                    |        |
| Hypertension                            | 200 (66.2)             | 95 (62.5)          | .432   |
| Diabetes mellitus                       | 86 (28.5)              | 48 (31.6)          | .494   |
| Dyslipidemia                            | 140 (46.4)             | 68 (44.7)          | .744   |
| COPD                                    | 49 (16.2)              | 45 (29.6)          | .001   |
| Atrial fibrillation                     | 37 (12.3)              | 19 (12.5)          | .939   |
| Myocardial infarction                   | 40 (13.3)              | 13 (8.6)           | .142   |
| Cerebrovascular disease                 | 26 (8.6)               | 9 (5.9)            | .311   |
| <i>Baseline medication</i>              |                        |                    |        |
| ACEi/ARB                                | 144 (47.7)             | 61 (40.1)          | .127   |
| Beta-blockers                           | 88 (29.1)              | 30 (19.7)          | .031   |
| Diuretic                                | 99 (32.8)              | 50 (32.9)          | .981   |
| <i>Symptoms on presentation</i>         |                        |                    |        |
| Chest pain                              | 82 (27.2)              | 40 (26.3)          | .850   |
| Progressive dyspnea                     | 129 (42.7)             | 88 (57.9)          | .002   |
| Paroxysmal nocturnal dyspnea            | 7 (2.3)                | 2 (1.3)            | .470   |
| Leg edema                               | 53 (17.6)              | 22 (14.5)          | .405   |
| Orthopnea                               | 21 (7.0)               | 6 (4.0)            | .201   |
| Cough                                   | 42 (13.9)              | 31 (20.4)          | .076   |
| Fever                                   | 25 (8.3)               | 35 (23.0)          | < .001 |
| <i>Vital signs on admission</i>         |                        |                    |        |
| Heart rate, bpm                         | 82.4 ± 19.8            | 88.3 ± 21.0        | .003   |
| SBP, mmHg                               | 138.5 ± 24.0           | 134.6 ± 26.0       | .143   |
| Oxygen saturation, %                    | 97 (96-99)             | 96 (93-98)         | .001   |
| <i>Signs on presentation</i>            |                        |                    |        |
| Heart murmur                            | 10 (3.3)               | 5 (3.3)            | .990   |
| Rales                                   | 93 (30.8)              | 55 (36.2)          | .248   |
| Wheezing                                | 38 (12.6)              | 33 (21.7)          | .012   |
| Peripheral edema                        | 69 (22.9)              | 28 (18.4)          | .278   |
| <i>AF on ECG<sup>a</sup></i>            | 18/195 (9.2)           | 22/107 (20.6)      | .005   |
| <i>Chest x-ray findings<sup>b</sup></i> |                        |                    |        |
| Interstitial edema                      | 31/282 (11.0)          | 36/147 (24.5)      | < .001 |
| Pleural effusion                        | 4/282 (1.4)            | 19/147 (12.9)      | < .001 |
| Cardiomegaly                            | 37/282 (13.1)          | 25/147 (17.0)      | .277   |
| <i>Laboratory results</i>               |                        |                    |        |
| Hemoglobin, g/dL                        | 13.1 ± 1.9             | 12.8 ± 2.1         | .224   |
| eGFR, mL/min/1.73 m <sup>2</sup>        | 85.9 ± 36.5            | 82.7 ± 34.3        | .382   |
| CRP, mg/dL <sup>c</sup>                 | 0.8 (0.4-2.8)          | 3.8 (0.8-10.7)     | < .001 |
| NT-proBNP, pg/mL                        | 242 (92-519)           | 433 (213-854)      | < .001 |

ACEi, angiotensin-converting enzyme inhibitor; AF, atrial fibrillation; ARB, angiotensin receptor blocker; bpm, beats per minute; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; ECG, electrocardiogram; eGFR, estimated glomerular filtration rate; NT-proBNP, N-terminal pro-B-type natriuretic peptide; SBP, systolic blood pressure.

Data are presented as mean ± standard deviation, median [interquartile range], or No. (%), as appropriate.

<sup>a</sup>ECG performed in 302 patients.

<sup>b</sup>Chest x-ray performed in 429 patients.

<sup>c</sup>CRP available in 400 patients.

**Table S5.** Clinical outcomes by hospital admission status: index-episode mortality and incidence rates of events restricted to index-episode survivors

|                                                                        | Not admitted  | Admitted       | <i>P</i> |
|------------------------------------------------------------------------|---------------|----------------|----------|
| <i>In-hospital mortality during index episode (n = 302 vs n = 152)</i> |               |                |          |
| Events                                                                 | 22 (7.3)      | 18 (11.8)      | .106     |
| <i>First heart failure readmission* (n = 280 vs n = 134)</i>           |               |                |          |
| Events                                                                 | 40 (14.3)     | 20 (14.9)      | .863     |
| Incidence rates (per 100 person-years)                                 | 5.9 (4.3-8.0) | 6.7 (4.3-10.3) |          |
| <i>All cause mortality* (n = 280 vs n = 134)</i>                       |               |                |          |
| Events                                                                 | 35 (12.5)     | 20 (14.9)      | .496     |
| Incidence rates (per 100 person-years)                                 | 5.0 (3.6-7.0) | 6.3 (4.0-9.7)  |          |

Unless otherwise specified, the data are expressed as No. (%).

\*First heart failure readmission and total mortality during follow-up were assessed after excluding patients who died during the index episode.

**Table S6.** Sensitivity analysis: gray-zone vs rule-out, restricted to discharged patients.

|                                           | Rule-out group (n<br>= 167) | Gray-zone group<br>(n = 113) | <i>P</i> |
|-------------------------------------------|-----------------------------|------------------------------|----------|
| <i>First heart failure readmission</i>    |                             |                              |          |
| Events                                    | 5 (3.0)                     | 26 (23.0)                    | < .001   |
| Incidence rates (per 100<br>person-years) | 1.1 (0.5-2.7)               | 11.4 (7.8-16.8)              |          |
| Unadjusted sHR (95%CI)                    | Reference                   | 8.7 (3.3-22.6)               |          |
| <i>Total mortality</i>                    |                             |                              |          |
| Events                                    | 2 (1.2)                     | 33 (29.2)                    | < .001   |
| Incidence rates (per 100<br>person-years) | 0.5 (0.1-1.8)               | 13.0 (9.2-18.3)              |          |
| Unadjusted HR (95%CI)                     | Reference                   | 27.3 (6.5-113.8)*            |          |

HR, hazard ratio; sHR, subdistribution hazard ratio; CI, confidence interval.

Unless otherwise specified, the data are expressed as No. (%).

Analysis restricted to patients discharged alive from the index emergency department visit (n = 280); excludes patients admitted to hospital and patients who died in the emergency department without hospital admission.

\*Interpret with caution given only 2 events in the reference group

**Table S7.** Gray zone vs rule-out restricted to patients aged  $\geq 75$  years: index-episode mortality and incidence rates of events restricted to index-episode survivors

|                                                                        | <i>Rule-out</i> | Gray-zone                     | <i>P</i> |
|------------------------------------------------------------------------|-----------------|-------------------------------|----------|
| <i>In-hospital mortality during index episode (n = 61 vs n = 171)</i>  |                 |                               |          |
| Events                                                                 | 1 (1.6)         | 29 (17.0)                     | .001     |
| <i>First heart failure readmission<sup>a</sup> (n = 60 vs n = 142)</i> |                 |                               |          |
| Events                                                                 | 2 (3.3)         | 37 (26.1)                     | < .001   |
| Incidence rates (per 100 person-years)                                 | 1.3 (0.3-5.1)   | 14.4 (10.4-19.8)              |          |
| Unadjusted sHR (95%CI)                                                 | Reference       | 9.3 (2.3-38.0)                |          |
| <i>All cause mortality<sup>a</sup> (n = 60 vs n = 142)</i>             |                 |                               |          |
| Events                                                                 | 1 (1.7)         | 45 (31.7)                     | < .001   |
| Incidence rates (per 100 person-years)                                 | 0.6 (0.1-4.5)   | 14.8 (11.1-19.9)              |          |
| Unadjusted HR (95%CI)                                                  | Reference       | 22.7 (3.1-164.5) <sup>b</sup> |          |

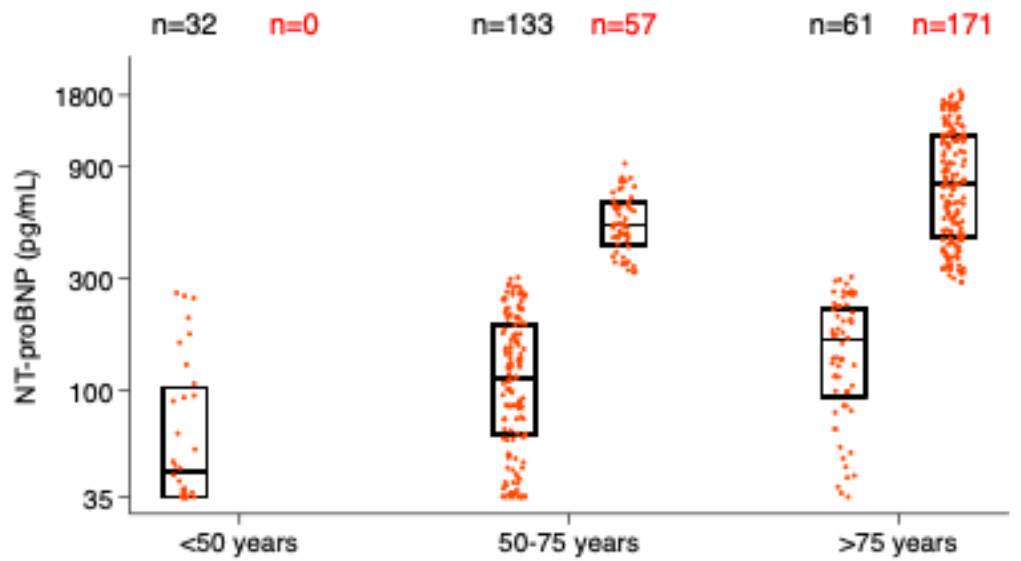
HR, hazard ratio; sHR, subdistribution hazard ratio; CI, confidence interval

Unless otherwise specified, the data are expressed as No. (%).

<sup>a</sup>Heart failure readmission and total mortality during follow-up were assessed after excluding patients who died during the index episode, restricting the analysis to index-episode survivors (rule-out, n = 60; gray zone, n = 142).

<sup>b</sup>Interpret with caution given the small number of events in the reference group.

**Figure S1.** Distribution of NT-proBNP values by age group and NT-proBNP classification. Strip plots showing the distribution of NT-proBNP values (log10 scale) in the rule-out and gray-zone groups across 3 age strata defined according to the age-adjusted NT-proBNP thresholds (< 50 years, 50-75 years, and >75 years). Boxes represent the interquartile range with median. Numbers above each plot indicate the number of patients in each subgroup. NT-proBNP, N-terminal pro-B-type natriuretic peptide.



**Figure S2.** Distribution of propensity scores for gray-zone classification, by group. Kernel density estimates of the propensity score (from the multivariable logistic model, averaged across the 20 multiply imputed datasets) are shown separately for the rule-out and gray-zone groups. Both distributions are shifted relative to each other, with limited overlap at the extremes and modest common support in the intermediate range (approximately 0.3-0.7).

