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# Baseline risk factors associated with all-cause early hospitalization of older patients following admission to Danish municipal temporary stays

Mahan Rajaeigolfsefidi<sup>1\*</sup>, Anton Pottegård<sup>2,3</sup>, Kasper Edwards<sup>1</sup> and Kathrin Kirchner<sup>1</sup>

## Abstract

**Background** Transitions from hospital to community are high-risk for older adults. In Denmark, municipal temporary stay (TS) facilities provide short-term, bed-based post-acute support, but determinants of early (re)hospitalization after TS admission are not well described. We estimated baseline risk factors for 30-day and 180-day hospitalization among TS patients.

**Methods** We performed a register-based cohort study that includes adults with TS admission in 14 municipalities (2016–2023). Individual-level linkages captured demographics, diagnosis history, healthcare-utilization markers, and characteristics of recent hospitalization episodes. Outcomes were all-cause hospitalization within 30 and 180 days after the index TS admission, with death treated as a competing event. We estimated cumulative incidence using the Aalen-Johansen method and fitted additive competing-risk regression with inverse failure probability weighting, which allows us to directly model absolute risk ratios (ARRs). Discrimination for 30-day risk was assessed with time-dependent c-index and Brier score using 3-fold cross-validation.

**Results** Among 11,284 patients (median age 81 years), 26.1% were hospitalized, and 7.6% died within 30 days without prior hospitalization. In adjusted models, male sex (ARR 1.16, 95% CI 1.09–1.24), higher multimorbidity (1–2 vs 0: 1.17, 1.04–1.31; ≥3 vs 0: 1.43, 1.27–1.61), and recent hospitalization (1.24, 1.14–1.34) increased 30-day risk, whereas older age decreased it per 10 years (0.96, 0.93–0.98). Several morbidities were associated with higher 30-day risk (cancer-related morbidities, cirrhosis, chronic kidney disease, chronic heart failure, atrial fibrillation, chronic pulmonary disease, diabetes), while dementia and prior stroke/TIA were associated with lower risk. Healthcare-utilization markers showed dose-response relations (≥4 prior hospitalizations: 1.58; ≥10 medications: 1.28; ≥3 procedures: 1.34). In the recently hospitalized subgroup, a fall-injury primary diagnosis reduced 30-day risk (0.88), recent surgery increased it (1.09), and hospital stays > 14 days conferred higher risk (1.31). The best 30-day model yielded a c-index of 0.623 and Brier score of 0.186.

\*Correspondence:  
Mahan Rajaeigolfsefidi  
mahraj@dtu.dk

Full list of author information is available at the end of the article



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**Conclusions** Early (re)hospitalization after TS admission is common and patterned by sex, multimorbidity, intensive prior healthcare use, and selected morbidities. Although model discrimination was modest, the identified risk factors can inform targeted interventions in transitional care delivered at TS settings.

**Clinical trial number** Not applicable.

**Keywords** Transitional care, Intermediate care, Post-acute care, Temporary stay, Older adults, Hospitalization, Hospital readmission, Risk regression, Competing risks, Denmark

## Background

Care transitions across healthcare settings are widely recognized as high-risk events, particularly for frail older patients [1]. Older adults often have complex health and social needs, and many experience complications leading to elevated adverse outcomes such as hospital readmissions [2, 3]. In response, health systems worldwide have developed intermediate or transitional care services to support patients during the post-acute period and mitigate these risks. Such services are designed to ensure continuity and coordination of care as patients transfer from hospital to the community, aiming to improve outcomes and prevent avoidable (re)hospitalizations [4–6]. These intermediate care models, variously termed hospital-at-home, step-down units, community rehabilitation beds, or other names, provide short-term, restorative care at the interface between hospital and home [4, 7–9].

In Denmark, municipal temporary stay (TS) facilities have been established across all 98 municipalities as an intermediate care solution for older patients who require short-term care that cannot be provided in their home. These facilities offer bed-based, 24-hour support typically after hospital discharge, though some patients are admitted directly from the community [10–13]. No centralized national guidelines for TS operations exist, and each municipality organizes its facilities independently. TS units are typically not required to have physicians on site, with medical responsibility falling to the patient's general practitioner or the discharging hospital [12].

Despite the expansion of TSs as a key component of health care in Denmark, empirical research on TS patient populations has been limited until recently. Two recent studies have begun to shed light on this patient group using a large cohort of 11,424 TS patients [13, 14]. The first study described medication use patterns [14], finding a median of 6 different drug classes used per patient, and that 68% of patients were on polypharmacy ( $\geq 5$  drug classes) at admission. High-risk medications were common, and the rate of new drug initiations spiked sharply upon entry into TS facilities. A second study explored TS patients' baseline characteristics and trajectories [13], revealing a heterogeneous profile of advanced age (median 81 years), high comorbidity burden, and substantial prior healthcare utilization. About 70% of TS admissions followed directly after a hospital discharge,

and the remaining 30% were admitted from the community. Notably, intermediate care did not eliminate the need for acute hospital care: 7% of patients in the cohort were transferred to a hospital during their TS episode, typically within the first two weeks of their stay, and in total, about 20% experienced a hospital admission within 30 days after discharge from TS. Although the baseline risk factors for 30-day mortality were analyzed, the study did not investigate the correlates of hospital admissions.

Health services research consistently uses readmission rates as an indicator of care quality and transition success [15–17], and risk factors for hospital readmission after acute discharge have been extensively studied internationally and in Denmark [18–22]. However, hospitalization after admission to an intermediate or transitional care facility such as TS represents a distinct scenario as patients admitted to these facilities comprise a subset of vulnerable adults who require additional support. As mentioned earlier, in Denmark, approximately 30% of TS admissions are not directly preceded by a hospital discharge [13], underscoring that TS patients represent a different case-mix than standard post-discharge cohorts. Risk factors of hospital return in this intermediate care context remain sparsely described [23–27], and to our knowledge, no prior studies have examined such risk factors in Danish TS patients. Moreover, intermediate care services are implemented heterogeneously worldwide with variations in admission criteria, patient case-mix, care goals, and staffing models [4]. Given this diversity, each care model warrants individual study to identify its outcomes and specific risk factors. Identifying correlates of early hospitalization in TS can facilitate risk stratification at admission, guiding targeted interventions for high-risk patients aimed at fulfilling one of TSs core objectives – preventing unnecessary hospitalizations. Accordingly, this study aims to identify and quantify baseline risk factors for 30-day and 180-day all-cause hospitalizations after admission to Danish municipal TS facilities.

## Methods

### Study design

We performed an observational, register-based cohort study using routinely collected Danish health and administrative data. The analysis focused on adults with at

least one TS admission between January 1, 2016, and December 31, 2023, in any of the 14 participating Danish municipalities (see supplementary material–Table A1 for a detailed list of municipalities and regions). The participating municipalities were recruited as a convenience sample via a national network of TS facility managers. Municipalities were invited with the pragmatic aim of including TS services from as many regions as possible, and the final sample spans four of the five Danish regions. Although not formally representative in a statistical sense, the study population is likely broadly representative of older adults using municipal TS facilities in Denmark.

#### Data sources

All records were linked at the individual level via the unique Central Person Register (CPR) number. Municipal TS records provided admission and discharge dates; the Civil Registration System supplied demographic characteristics (date of birth, sex) together with migration and death dates [28]; hospital contacts and ICD-10 discharge diagnoses were retrieved from the Danish National Patient Registry (DNPR) [29], and Health Care Classification System (SKS) procedure codes within the DNPR identified surgical interventions [30, 31]; finally, information on dispensed prescriptions, coded according to the Anatomical Therapeutic Chemical (ATC) scheme, was obtained from the Danish National Prescription Registry [32]. All registries are nationwide, continuously updated, and regarded as virtually complete for the variables included.

#### Assembly of the analytic cohort and follow-up

The source population comprised 11,584 individuals with at least one TS episode falling entirely within the 2016–2023 window. We excluded 300 persons who had lived outside Denmark at any point during the five years preceding their first TS admission because their registry histories were potentially incomplete, leaving a final cohort of 11,284 patients. Patients with multiple stays contributed only their first episode. This approach yielded one observation per individual. The end of observation was April 4, 2024. Patients were followed prospectively until the first hospitalization episode or death after the index TS admission date, or until the end of observation, whichever came first.

#### Variables

The primary outcome variable of interest was all-cause hospitalization within 30 days after the index TS admission. However, to investigate longer-term associations and the potential differences in short-term versus longer-term trajectories, we also analyzed 180-day hospitalization and the associated risk factors. We included death

as a competing outcome. Sex, as assigned at birth, and age at the time of index TS admission were included as demographic variables. A set of 27 morbidities was identified using the primary diagnosis history of inpatient hospital contacts over the 5-year window prior to index TS admission. The ICD-10 mapping utilized to identify morbidities is presented in supplementary material–Table A2. Multimorbidity was defined as the number of morbidities identified in each patient. Recent hospitalization, a binary variable, was defined as whether the patient had a hospitalization that ended within seven days prior to the index TS admission. Hospitalization burden, polypharmacy, and frequency of surgeries were calculated, respectively, as the number of inpatient hospital contacts, unique prescribed medications at the fourth ATC level, and surgical interventions within 12 months before the index TS admission. When identifying surgical procedures, we excluded specific SKS codes as presented in the supplementary material–Table A3.

For patients with a recent hospitalization, we calculated three variables derived from their recent hospitalization episode. We identified fall injuries based on the primary diagnoses of recent hospitalizations using ICD-10 mapping of supplementary material–Table A4. We also determined whether a patient had undergone surgical interventions during a recent hospitalization. The length of stay of the recent hospitalization episode was also calculated. If a patient had more than one recent hospitalization per definition, we calculated the cumulative length of stay.

#### Analytic process

All calculations and analyses were performed using R version 4.4.3. We obtained cumulative incidence functions (CIFs) of hospitalization, considering death as a competing outcome, using the Aalen-Johansen method [33]. The Aalen-Johansen CIFs, stratified by sex, age group, multimorbidity level, and recent hospitalization, were plotted for the first 180 days after the index TS admission. We used the estimations of CIF to calculate median time-to-hospitalization, and via bootstrapping with 1,000 resamples, we derived the 95% confidence intervals (CI). We employed the Kaplan-Meier method to calculate the median time-to-death, and the 95% CIs were constructed using the log-minus-log transformation method. These time-to-event estimates, together with counts and proportions of 30-day hospitalization and death, were reported stratified by sex, age group, multimorbidity level, recent hospitalization, and individual selected morbidities. Throughout the rest of the analysis, we assessed the association of different variables with short-term and longer-term future hospitalization, using the 30-day and 180-day absolute risk ratios (ARRs).

ARRs were estimated using an additive absolute risk regression model developed by Scheike and Zhang [34]. This approach directly models absolute risk over time, rather than cause-specific hazards, allowing for intuitive interpretation of relative risks. The model accounts for competing risk of death and adjusts for confounding using inverse failure probability weighting (IFPW), which corrects for censoring by reweighting individuals according to the inverse probability of remaining uncensored [35]. The censoring distribution required for IFPW was estimated using the Kaplan-Meier method. Although patients were potentially followed beyond 30 or 180 days, follow-up data after each time window did not contribute to the respective estimated risks. The 95% CIs were derived from robust sandwich variance estimators, based on asymptotic distribution of the estimating equations [34]. Our cohort includes older multimorbid patients as described in previous studies [13]. Therefore, we chose the competing risk framework to avoid obtaining biased results and overestimating the risk of early hospitalization due to the violation of non-informative censoring by treating death as a censoring event [36].

When conducting risk regression, including all variables simultaneously would adjust for factors that are plausibly on the causal pathway, yielding controlled direct rather than total effects and risking overadjustment or collider bias. We therefore used a pre-specified block-wise strategy. The analysis of risk factors associated with hospitalization after TS admission was conducted in four steps. First, age, sex, multimorbidity, and recent hospitalization were evaluated using both univariate models and an adjusted model including all four variables. Second, the association of each morbidity with hospitalization was assessed adjusting for age, sex, and multimorbidity as the core baseline covariates. Morbidities for which we found significant 30-day ARR ( $p < 0.05$ ) were then added to the covariates list for future steps. Third, the association of healthcare utilization markers, including one-year history of hospitalization burden, polypharmacy, and frequency of surgery, was analyzed adjusting for the full set of covariates determined in previous steps. Finally, in the fourth step, we only included the subset of the cohort with a recent hospitalization prior to the index TS admission. Within this subset of patients, in addition to variables assessed in the third step, three new variables related to the recent hospitalization episodes, i.e., primary diagnoses of fall injury, surgical interventions, and length of stay at hospital, were analyzed. The models for each variable were adjusted for the complete set of covariates determined at the second step.

Finally, to evaluate the discriminant ability of the identified risk factors for 30-day hospitalization, several combinations of significant variables were used for risk prediction (see supplementary material–Table A5).

Time-dependent concordance (c-index) and Brier scores were calculated for each model using 3-fold cross-validation. Additionally, the discriminant performance of the risk regression method used in this study [34] was compared with the widely used Fine-Gray method [37].

## Results

Overall, early adverse outcomes after TS admission were frequent. Within 30 days, almost 26% of patients were hospitalized, and roughly 8% died without prior hospitalization. Higher hospitalization risks over 30 and 180 days were consistently observed in men, patients with greater multimorbidity, selected chronic conditions (including chronic heart failure, chronic kidney disease, cancers, cirrhosis, chronic pulmonary disease, and diabetes), and those with intensive prior healthcare use (recent hospitalization, repeated admissions, polypharmacy, and multiple surgeries). In contrast, advancing age, dementia, and previous stroke/TIA were associated with lower hospitalization risk. At the same time, among recently hospitalized patients, a fall-injury index diagnosis was associated with a lower risk, while recent surgery and hospital stays longer than 14 days were associated with an increased risk.

The study population had a median age of 81 years (interquartile range [IQR] 73–87). The baseline characteristics of the study population are reported in Table 1. The median time-to-hospitalization of the cohort was 7 months (IQR 1–47). The median time-to-death was 24 months (IQR 4–60). Figure 1 illustrates the CIFs of hospitalization and death over 180 days. Male sex, younger age groups, higher multimorbidity burden, and recent hospitalization demonstrated higher probabilities of hospitalization over time.

### Age, sex, multimorbidity, and recent hospitalization (step 1)

In mutually adjusted models (Table 2), each 10-year increase in age was associated with lower 30-day absolute risk (adjusted ARR [aARR] 0.96, 95% CI 0.93–0.98). Male patients experienced a higher risk than females (aARR 1.16, 95% CI 1.09–1.24). A clear dose-response with multimorbidity was evident: compared with patients without recorded morbidities, those with 1–2 morbidities had 17% higher 30-day risk (aARR 1.17, 95% CI 1.04–1.31), while patients with  $\geq 3$  morbidities showed 43% increase (aARR 1.43, 95% CI 1.27–1.61). A recent hospital stay (within seven days before the TS admission) remained an independent predictor, raising 30-day risk (aARR 1.24, 95% CI 1.14–1.34). Longer-term 180-day associations were in the same direction as the 30-day risks, but the effect sizes were smaller in magnitude. Univariate estimates were directionally consistent but slightly larger in magnitude.

**Table 1** Baseline characteristics of study population in terms of hospitalization and death outcomes

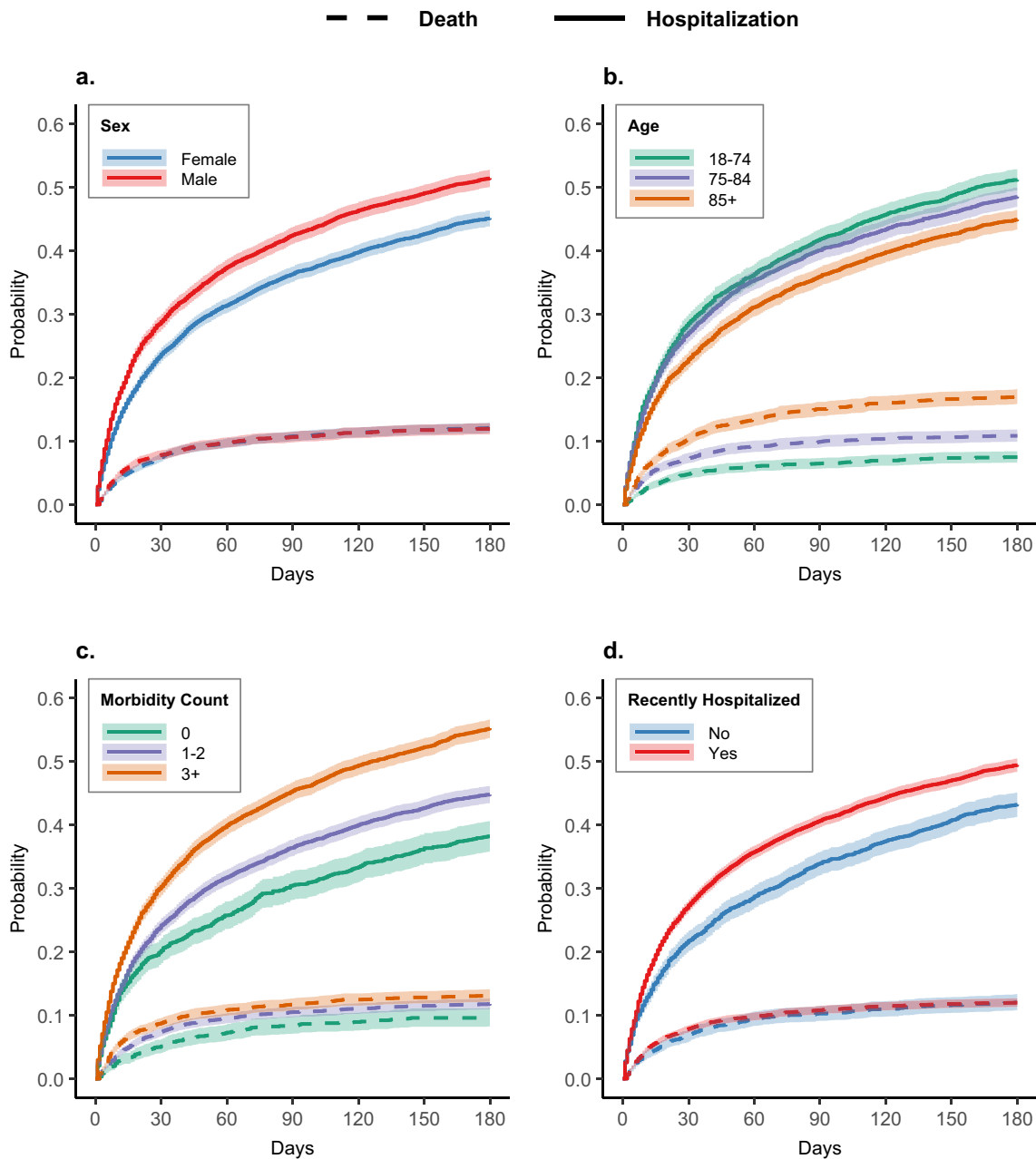
|                             | N (%)       | Median time-to-event, months (95% CI) |                  | Count (%) of 30-day outcomes |            |
|-----------------------------|-------------|---------------------------------------|------------------|------------------------------|------------|
|                             |             | Hospitalization                       | Death            | Hospitalization              | Death      |
| Full cohort                 | 11284 (100) | 7.0 (6.4–7.5)                         | 23.8 (22.8–24.8) | 2941 (26.1)                  | 861 (7.6)  |
| Stratified by:              |             |                                       |                  |                              |            |
| Age                         |             |                                       |                  |                              |            |
| 18–74                       | 3340 (29.6) | 5.3 (4.9–6.2)                         | 43.5 (40.5–47.3) | 954 (28.6)                   | 161 (4.8)  |
| 75–84                       | 3982 (35.3) | 6.6 (5.9–7.5)                         | 25.4 (24.1–27.0) | 1079 (27.1)                  | 292 (7.3)  |
| 85+                         | 3962 (35.3) | 9.0 (8.0–10.1)                        | 14.1 (13.0–15.1) | 908 (22.9)                   | 408 (10.3) |
| Sex                         |             |                                       |                  |                              |            |
| Female                      | 6076 (53.8) | 8.8 (8.1–9.8)                         | 26.7 (25.5–28.2) | 1440 (23.7)                  | 453 (7.5)  |
| Male                        | 5208 (46.2) | 5.2 (4.8–5.8)                         | 20.2 (18.2–21.6) | 1501 (28.8)                  | 408 (7.8)  |
| Multimorbidity              |             |                                       |                  |                              |            |
| 0                           | 1566 (13.9) | 13.4 (11.0–16.0)                      | 33.6 (29.8–36.3) | 316 (20.2)                   | 80 (5.1)   |
| 1–2                         | 5215 (46.2) | 8.7 (8.1–9.8)                         | 27.4 (25.5–29.0) | 1261 (24.2)                  | 387 (7.4)  |
| 3+                          | 4503 (39.9) | 4.1 (3.7–4.6)                         | 16.7 (15.6–18.1) | 1364 (30.3)                  | 394 (8.7)  |
| Recent hospitalization      |             |                                       |                  |                              |            |
| No                          | 2544 (22.5) | 9.8 (8.6–11.0)                        | 20.7 (18.9–22.8) | 553 (21.7)                   | 173 (6.8)  |
| Yes                         | 8740 (77.5) | 6.2 (5.6–6.8)                         | 24.8 (23.7–25.9) | 2388 (27.3)                  | 688 (7.9)  |
| 5-year history of           |             |                                       |                  |                              |            |
| Alcohol misuse              | 832 (7.4)   | 5.3 (4.1–6.9)                         | 34.7 (30.2–40.6) | 236 (28.4)                   | 40 (4.8)   |
| Asthma                      | 342 (3.0)   | 4.8 (2.9–7.3)                         | 27.7 (21.4–36.5) | 102 (29.8)                   | 20 (5.8)   |
| Atrial fibrillation         | 2559 (22.7) | 4.3 (3.6–5.0)                         | 14.5 (12.7–16.0) | 757 (29.6)                   | 243 (9.5)  |
| Cancer, lymphoma            | 228 (2.0)   | 1.7 (1.1–2.7)                         | 7.0 (4.3–9.2)    | 95 (41.7)                    | 28 (12.3)  |
| Cancer, metastatic          | 483 (4.3)   | 5.6 (3.1–11.9)                        | 1.6 (1.4–2.1)    | 160 (33.1)                   | 125 (25.9) |
| Cancer, non-metastatic      | 1316 (11.7) | 5.0 (3.7–6.4)                         | 6.0 (4.7–7.5)    | 417 (31.7)                   | 205 (15.6) |
| Chronic heart failure       | 1189 (10.5) | 3.3 (2.7–4.1)                         | 10.4 (8.4–13.0)  | 393 (33.1)                   | 133 (11.2) |
| Chronic kidney disease      | 1468 (13.0) | 3.2 (2.7–3.7)                         | 14.1 (11.9–16.0) | 485 (33.0)                   | 136 (9.3)  |
| Chronic pain                | 2025 (17.9) | 4.8 (4.0–5.3)                         | 27.7 (25.2–30.5) | 562 (27.8)                   | 130 (6.4)  |
| Chronic pulmonary disease   | 1579 (14.0) | 3.7 (3.1–4.7)                         | 13.6 (12.2–15.2) | 496 (31.4)                   | 149 (9.4)  |
| Cirrhosis                   | 219 (1.9)   | 1.8 (1.1–3.4)                         | 13.8 (9.2–17.3)  | 89 (40.6)                    | 14 (6.4)   |
| Dementia                    | 1191 (10.6) | 13.8 (11.2–16.8)                      | 21.8 (19.1–24.1) | 225 (18.9)                   | 82 (6.8)   |
| Depression                  | 601 (5.33)  | 5.1 (4.1–7.1)                         | 26.9 (23.2–30.8) | 170 (28.3)                   | 43 (7.1)   |
| Diabetes                    | 1850 (16.4) | 3.6 (3.1–4.4)                         | 19.7 (17.3–22.4) | 603 (32.6)                   | 127 (6.9)  |
| Epilepsy                    | 383 (3.4)   | 4.0 (3.0–5.6)                         | 27.4 (21.1–34.3) | 104 (27.2)                   | 21 (5.5)   |
| Hypertension                | 4079 (36.1) | 5.3 (5.0–6.0)                         | 22.7 (20.7–24.2) | 1120 (27.5)                  | 297 (7.3)  |
| Hypothyroidism              | 394 (3.5)   | 6.0 (4.4–8.6)                         | 20.5 (14.7–26.8) | 103 (26.1)                   | 30 (7.6)   |
| Inflammatory bowel disease  | 114 (1.0)   | 4.8 (2.2–11.0)                        | 28.8 (23.0–47.9) | 37 (32.5)                    | 6 (5.3)    |
| Multiple sclerosis          | 92 (0.8)    | 5.0 (2.7–9.8)                         | 63.2 (51.4–NR)   | 26 (28.3)                    | < 5        |
| Myocardial infarction       | 435 (3.9)   | 5.4 (3.7–7.5)                         | 18.9 (15.1–25.2) | 121 (27.8)                   | 46 (10.6)  |
| Parkinson's disease         | 336 (3.0)   | 5.1 (4.0–7.1)                         | 25.5 (21.1–30.4) | 88 (26.2)                    | 12 (3.6)   |
| Peptic ulcer disease        | 138 (1.2)   | 3.8 (2.4–7.2)                         | 18.6 (10.1–25.8) | 38 (27.5)                    | 12 (8.7)   |
| Peripheral vascular disease | 1061 (9.4)  | 4.2 (3.3–5.3)                         | 16.1 (13.7–18.4) | 334 (31.5)                   | 102 (9.6)  |
| Psoriasis                   | 98 (0.9)    | 6.0 (2.8–13.8)                        | 32.5 (20.2–46.8) | 23 (23.5)                    | 7 (7.1)    |
| Rheumatoid arthritis        | 395 (3.5)   | 4.5 (3.0–5.8)                         | 18.8 (13.6–24.8) | 118 (29.9)                   | 34 (8.6)   |
| Schizophrenia               | 75 (0.7)    | 8.2 (3.8–19.3)                        | 48.9 (28.0–NR)   | 14 (18.7)                    | < 5        |
| Stroke or TIA               | 2345 (20.8) | 6.6 (5.6–7.4)                         | 28.1 (26.1–30.8) | 571 (24.3)                   | 146 (6.2)  |

NR = upper confidence limit not reached; the 95% upper confidence band for the survival curve remained above 0.50 for the entire follow-up period

### Morbidities (step 2)

As shown in Table 3, after adjustment for the three core baseline covariates, the most substantial increases in both the 30-day and the 180-day absolute risks were seen for lymphoma, cirrhosis, and chronic kidney disease, followed by atrial fibrillation, chronic heart failure, chronic

pulmonary disease, and diabetes. Notably, metastatic and non-metastatic cancers increased the 30-day risk, but their effect on longer-term risk did not reach statistical significance, highlighting a divergence between early readmission propensity and longer-term trajectories. Dementia and stroke/transient ischaemic attack



**Fig. 1** Stratified cumulative incidence functions (95% CI band) of hospitalization and the competing outcome of death

were associated with significantly lower hospitalization risk across both time horizons. The 11 morbidities with significant 30-day ARR ( $p < 0.05$ ) were therefore carried forward as additional adjustment factors in subsequent analytic steps, together with the three core baseline covariates.

**Healthcare-utilization markers (step 3)**

After adjustment for core baseline and morbidity covariates, each of the three utilization indicators—one-year history of hospitalization burden, polypharmacy, and frequency of surgery—retained an independent

association with subsequent hospitalization (Table 4). Relative to patients with  $\leq 1$  inpatient hospital contacts, those with 2–3 contacts exhibited 27% higher 30-day absolute risk (aARR 1.27, 1.13–1.43), while those with  $\geq 4$  contacts showed an increase of 58% (aARR 1.58, 1.41–1.77). Medication count displayed a similar dose-response: compared with  $\leq 4$  unique drugs, prescriptions of 5–9 and  $\geq 10$  drugs were associated with 15% (aARR 1.15, 1.03–1.27) and 28% (aARR 1.28, 1.16–1.42) higher 30-day risks, respectively. Prior surgical activity also predicted hospitalization: one to two procedures conferred an aARR of 1.23 (1.13–1.33), whereas three or more

**Table 2** Analysis of the association of age, sex, multimorbidity, and recent hospitalization with consequent hospitalization

| Variable in analysis   | 30-day hospitalization     |                            | 180-day hospitalization    |                            |
|------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|                        | uARR <sup>1</sup> (95% CI) | aARR <sup>2</sup> (95% CI) | uARR <sup>1</sup> (95% CI) | aARR <sup>2</sup> (95% CI) |
| Age*                   | 0.94 (0.92–0.97)           | 0.96 (0.93–0.98)           | 0.95 (0.94–0.97)           | 0.96 (0.95–0.98)           |
| Sex                    |                            |                            |                            |                            |
| Female                 | reference                  | reference                  | reference                  | reference                  |
| Male                   | 1.22 (1.14–1.29)           | 1.16 (1.09–1.24)           | 1.14 (1.1–1.19)            | 1.09 (1.05–1.14)           |
| Morbidity Count        |                            |                            |                            |                            |
| 0                      | reference                  | reference                  | reference                  | reference                  |
| 1–2                    | 1.20 (1.07–1.34)           | 1.17 (1.04–1.31)           | 1.17 (1.09–1.26)           | 1.15 (1.07–1.24)           |
| 3+                     | 1.50 (1.34–1.69)           | 1.43 (1.27–1.61)           | 1.45 (1.34–1.56)           | 1.40 (1.30–1.51)           |
| Recent Hospitalization |                            |                            |                            |                            |
| No                     | reference                  | reference                  | reference                  | reference                  |
| Yes                    | 1.26 (1.16–1.36)           | 1.24 (1.14–1.34)           | 1.14 (1.09–1.20)           | 1.13 (1.08–1.19)           |

1. unadjusted ARR; 2. adjusted ARR by including all four covariates.; \* per 10 unit increase in age

**Table 3** Association of selected morbidities with consequent hospitalization

| Variable in analysis        | 30-day Hospitalization       |         | 180-day Hospitalization      |         |
|-----------------------------|------------------------------|---------|------------------------------|---------|
|                             | aARR <sup>SAM</sup> (95% CI) | p-value | aARR <sup>SAM</sup> (95% CI) | p-value |
| Alcohol misuse              | 0.93 (0.83–1.05)             | 0.25    | 0.93 (0.87–1.00)             | 0.05    |
| Asthma                      | 1.04 (0.89–1.22)             | 0.61    | 0.98 (0.89–1.08)             | 0.65    |
| Atrial fibrillation*        | 1.09 (1.01–1.17)             | 0.04    | 1.08 (1.03–1.14)             | <0.001  |
| Cancer, lymphoma*           | 1.48 (1.26–1.74)             | <0.0001 | 1.25 (1.13–1.38)             | <0.0001 |
| Cancer, metastatic*         | 1.16 (1.02–1.33)             | 0.03    | 0.94 (0.86–1.04)             | 0.24    |
| Cancer, non-metastatic*     | 1.15 (1.05–1.25)             | <0.01   | 0.99 (0.94–1.06)             | 0.95    |
| Chronic heart failure*      | 1.15 (1.05–1.27)             | <0.01   | 1.12 (1.05–1.18)             | <0.001  |
| Chronic kidney disease*     | 1.17 (1.07–1.28)             | <0.001  | 1.15 (1.09–1.21)             | <0.0001 |
| Chronic pain                | 0.99 (0.91–1.07)             | 0.76    | 1.04 (0.99–1.09)             | 0.07    |
| Chronic pulmonary disease*  | 1.12 (1.02–1.22)             | 0.01    | 1.08 (1.02–1.14)             | <0.01   |
| Cirrhosis*                  | 1.34 (1.13–1.59)             | <0.001  | 1.19 (1.07–1.32)             | <0.001  |
| Dementia*                   | 0.67 (0.59–0.76)             | <0.0001 | 0.76 (0.71–0.82)             | <0.0001 |
| Depression                  | 0.97 (0.85–1.11)             | 0.69    | 0.98 (0.91–1.06)             | 0.68    |
| Diabetes*                   | 1.16 (1.06–1.26)             | <0.001  | 1.09 (1.03–1.14)             | <0.01   |
| Epilepsy                    | 0.90 (0.76–1.07)             | 0.25    | 1.05 (0.95–1.15)             | 0.35    |
| Hypertension                | 0.95 (0.89–1.03)             | 0.22    | 0.99 (0.95–1.04)             | 0.74    |
| Hypothyroidism              | 0.96 (0.81–1.13)             | 0.62    | 0.97 (0.88–1.07)             | 0.58    |
| Inflammatory bowel disease  | 1.10 (0.85–1.44)             | 0.46    | 0.94 (0.78–1.12)             | 0.48    |
| Multiple sclerosis          | 1.02 (0.73–1.41)             | 0.92    | 1.04 (0.86–1.25)             | 0.71    |
| Myocardial infarction       | 0.95 (0.81–1.11)             | 0.52    | 0.96 (0.88–1.06)             | 0.44    |
| Parkinson's disease         | 0.93 (0.77–1.12)             | 0.45    | 1.04 (0.94–1.16)             | 0.43    |
| Peptic ulcer disease        | 0.95 (0.72–1.25)             | 0.72    | 1.04 (0.89–1.22)             | 0.61    |
| Peripheral vascular disease | 1.09 (0.99–1.21)             | 0.09    | 1.03 (0.97–1.10)             | 0.33    |
| Psoriasis                   | 0.77 (0.54–1.10)             | 0.16    | 0.89 (0.72–1.09)             | 0.27    |
| Rheumatoid arthritis        | 1.08 (0.92–1.26)             | 0.35    | 1.08 (0.99–1.19)             | 0.10    |
| Schizophrenia               | 0.64 (0.40–1.02)             | 0.06    | 0.83 (0.64–1.06)             | 0.14    |
| Stroke or TIA*              | 0.83 (0.76–0.90)             | <0.0001 | 0.94 (0.89–0.98)             | 0.01    |

aARR<sup>SAM</sup> = absolute risk ratio adjusted for sex, age, and multimorbidity

\* Significant morbidities

procedures increased the aARR to 1.34 (1.24–1.44). All 180-day associations were smaller in magnitude, and in the case of polypharmacy, prescriptions of 5–9 drugs did not increase the 180-day risk significantly compared with  $\leq 4$  drugs.

#### Characteristics of the recent hospitalization (step 4)

Among the 8740 patients whose index TS admission was preceded by a hospital discharge within seven days, the annual patterns of healthcare use remained influential. However, their impact differed across levels and between early and longer-term readmission horizons (Table 5).

**Table 4** Association of healthcare-utilization indicators with subsequent hospitalization

| Variable in analysis               | Count (%)   | 30-day Hospitalization        |          | 180-day Hospitalization       |          |
|------------------------------------|-------------|-------------------------------|----------|-------------------------------|----------|
|                                    |             | aARR <sup>SAMM</sup> (95% CI) | p-value  | aARR <sup>SAMM</sup> (95% CI) | p-value  |
| 1-year history of Hospitalizations |             |                               |          |                               |          |
| 0–1                                | 1835 (16.3) | reference                     | –        | reference                     | –        |
| 2–3                                | 3885 (34.4) | 1.27 (1.13–1.43)              | < 0.0001 | 1.10 (1.03–1.18)              | < 0.01   |
| 4+                                 | 5564 (49.3) | 1.58 (1.41–1.77)              | < 0.0001 | 1.29 (1.21–1.38)              | < 0.0001 |
| Unique prescriptions               |             |                               |          |                               |          |
| 0–4                                | 1919 (17.0) | reference                     | –        | reference                     | –        |
| 5–9                                | 3877 (34.4) | 1.15 (1.03–1.27)              | < 0.01   | 1.06 (0.99–1.13)              | 0.08     |
| 10+                                | 5488 (48.6) | 1.28 (1.16–1.42)              | < 0.0001 | 1.20 (1.13–1.28)              | < 0.0001 |
| Surgical procedures                |             |                               |          |                               |          |
| 0                                  | 6252 (55.4) | reference                     | –        | reference                     | –        |
| 1–2                                | 2454 (21.7) | 1.23 (1.13–1.33)              | < 0.0001 | 1.10 (1.04–1.15)              | < 0.001  |
| 3+                                 | 2578 (22.8) | 1.34 (1.24–1.44)              | < 0.0001 | 1.18 (1.13–1.23)              | < 0.0001 |

aARR<sup>SAMM</sup> = absolute risk ratio adjusted for sex, age, multimorbidity, and significant morbidities

**Table 5** Association of characteristics of recently-hospitalized patients with subsequent hospitalization (N=8740)

| Variable in analysis               | Count (%)   | 30-day Hospitalization        |          | 180-day Hospitalization       |          |
|------------------------------------|-------------|-------------------------------|----------|-------------------------------|----------|
|                                    |             | aARR <sup>SAMM</sup> (95% CI) | p-value  | aARR <sup>SAMM</sup> (95% CI) | p-value  |
| 1-year history of Hospitalizations |             |                               |          |                               |          |
| 0–1                                | 667 (7.6)   | reference                     | –        | reference                     | –        |
| 2–3                                | 3307 (37.8) | 1.14 (0.96–1.35)              | 0.14     | 1.00 (0.91–1.11)              | 0.97     |
| 4+                                 | 4766 (54.5) | 1.41 (1.19–1.68)              | < 0.0001 | 1.17 (1.06–1.29)              | < 0.01   |
| Unique prescriptions               |             |                               |          |                               |          |
| 0–4                                | 1531 (17.5) | reference                     | –        | reference                     | –        |
| 5–9                                | 3038 (34.8) | 1.15 (1.02–1.29)              | 0.02     | 1.05 (0.98–1.13)              | 0.17     |
| 10+                                | 4171 (47.7) | 1.33 (1.18–1.49)              | < 0.0001 | 1.21 (1.12–1.30)              | < 0.0001 |
| Surgical procedures                |             |                               |          |                               |          |
| 0                                  | 4514 (51.6) | reference                     | –        | reference                     | –        |
| 1–2                                | 2063 (23.6) | 1.18 (1.08–1.28)              | < 0.001  | 1.05 (1.00–1.11)              | 0.05     |
| 3+                                 | 2163 (24.7) | 1.27 (1.16–1.38)              | < 0.0001 | 1.14 (1.08–1.20)              | < 0.0001 |
| Recent hospitalization             |             |                               |          |                               |          |
| Fall injury                        | 1752 (20.0) | 0.88 (0.80–0.98)              | 0.02     | 0.92 (0.87–0.98)              | 0.01     |
| Surgery                            | 2077 (23.8) | 1.09 (1.01–1.18)              | 0.04     | 1.04 (0.97–1.09)              | 0.16     |
| Length of stay                     |             |                               |          |                               |          |
| 1–7 days                           | 2756 (31.5) | reference                     | –        | reference                     | –        |
| 8–14 days                          | 3839 (43.9) | 1.14 (1.05–1.24)              | < 0.01   | 1.05 (1.00–1.11)              | 0.05     |
| > 14 days                          | 2145 (24.5) | 1.31 (1.19–1.43)              | < 0.0001 | 1.13 (1.07–1.20)              | < 0.0001 |

aARR<sup>SAMM</sup> = absolute risk ratio adjusted for sex, age, multimorbidity, and significant morbidities

Three variables that characterized the recent hospital episode also proved informative. A primary diagnosis of fall injury was associated with lower 30-day risk (aARR 0.88, 0.80–0.98) and also lower 180-day risk (aARR 0.92, 0.80–0.98). If that recent stay involved a surgical intervention, 30-day risk increased (aARR 1.09, 1.01–1.18), but the effect on 180-day risk was insignificant. Finally, length of hospital stay displayed a clear trend in the 30-day risk: 8–14 days versus 1–7 days yielded aARR 1.14 (1.05–1.24) and stays exceeding 14 days elevated the risk by 31% (aARR 1.31, 1.19–1.43). Regarding 180-day risk,

only stays exceeding 14 days increased the risk (aARR 1.13, 1.07–1.20).

#### Discriminant ability of risk factors and models

Among several combinations of variables used to predict 30-day hospitalization risks in the complete cohort, the full model including sex, age, multimorbidity, recent hospitalization, significant morbidities, and healthcare-utilization markers performed best (see supplementary material–Table A5) with a c-index of 0.6225 (95% CI 0.6108–0.6342) and the Brier score being 0.1861 (95% CI 0.1822–0.1899). In similar risk prediction tasks within

the recently hospitalized patients, adding variables of the recent hospitalization episode, i.e., primary diagnosis of fall injury, surgery, and length of stay, did not significantly improve either the c-index ( $p=0.53$ ) or the Brier score ( $p=0.12$ ). The risk regression method used in this study outperformed the Fine-Gray method in most models, and a similar performance was observed in the baseline models including only sex, age, multimorbidity, or recent hospitalization (see supplementary material–Table A6).

## Discussion

This study addresses a notable evidence gap, as risk factors for early hospitalization in intermediate care settings have been scarcely studied, and none have focused on Danish TS patients. By identifying which TS patients are most vulnerable to early hospitalization, our findings provide critical insight to inform and improve transitional care for this high-risk population. We examined risk factors for all-cause 30-day hospital (re)admissions among mostly older patients entering Danish municipal TS facilities. Our study utilized a large cohort of TS patients from 14 municipalities distributed across four out of five regions of Denmark (see supplementary material–Table A1). To our knowledge, this is the first systematic research on baseline risk factors of early hospitalization among Danish TS patients. Overall, our results demonstrated both concordance with and divergence from the existing literature. Key predictors, such as high multimorbidity and intensive prior healthcare use, mirrored and confirmed findings in other geriatric populations. In contrast, factors like advanced age, dementia, and previous stroke/TIA showed associations opposite to those typically reported in hospital-based cohorts, highlighting a divergence. These discrepancies likely reflect unique aspects of the Danish TS care model and differences in patient case-mix, underscoring the added value of our context-specific findings.

We found that having multiple chronic conditions was a key determinant of (re)hospitalization. This aligns with a broad literature identifying high comorbidity burdens as a major risk factor for post-acute readmissions [18, 19, 26, 27]. Similarly, our finding that higher levels of previous health care utilization, including polypharmacy, history of frequent hospitalizations and surgeries, having a recent hospitalization prior to TS admission, and prolonged previous hospital stay, increase the risk of return to acute care corroborates prior research in geriatric cohorts [24, 26, 38, 39]. The overlap in risk profiles suggests that, regardless of setting, patients with complex medical needs and intense prior healthcare utilization are vulnerable to cycling back to the hospital.

Our results showed that male patients have a higher hospitalization risk as observed in several studies on geriatric rehabilitation units in Scotland and the United

States [25, 40, 41] and other geriatric cohorts [21, 42, 43]. However, there are other studies in the United States and Australia reporting no association between sex and hospitalization risk [23, 24, 26, 44]. Although there is no definitive explanation for the increased risk of hospitalization in men, some studies have hypothesized differences in health-seeking behaviors and adherence to treatment as a possible underlying factor [25, 43].

One notable divergence from some prior research was the role of age. We observed that increasing age was protective against hospitalization. Another study similarly reported a reduced readmission risk with older age in a rehabilitation setting [25], contrary to several other studies where advanced age either predicted higher readmissions [40, 41] or showed no significant association [23, 24, 26, 44]. This discrepancy likely reflects selection and competing risk factors. The oldest frail patients in Denmark may be more often transitioned to long-term care or palliative pathways instead of hospital readmission, and some may have higher mortality, which we accounted for as a competing risk. As Fig. 1.b shows, older age groups have a higher probability of mortality without experiencing hospitalization over the 180-day follow-up.

Our analysis also highlighted specific chronic conditions associated with increased risk of 30-day hospitalization. We reported that chronic heart failure, atrial fibrillation, lymphoma, metastatic and non-metastatic cancer, chronic pulmonary disease, chronic kidney disease, cirrhosis, and diabetes are associated with increased risk of early hospitalization. These results are well-supported by prior research on both general and older adult populations [18, 24, 25, 42, 45]. A notable observation was the insignificant association of metastatic and non-metastatic cancer with longer-term hospitalization risk. In our cohort, patients with metastatic and non-metastatic cancer had very short median survival times (1.6 months and 6 months, respectively). Thus, we speculate that such severe conditions might shift the outcome balance toward mortality or end-of-life care rather than repeat hospitalization. However, this does not explain the consistent increase in risk of 30-day and 180-day hospitalization in patients with lymphoma who also had a short median survival time (7 months). Interestingly, we observed that dementia, previous stroke, and recent fall injuries were associated with lower hospitalization risk, possibly due to selection. In a previous study, dementia and fall injuries were found to be protective against early mortality in TS patients, highlighting the possibility that these patients are admitted to TS for less critical needs [13].

Although we discussed selection, competing risks, and the shift in care goals as possible explanations for the protective roles of older age, dementia, and prior stroke

against early hospitalization, we can also speculate that the Danish intermediate care model including municipal TS facilities and home care services, combined with primary care could effectively mitigate the risk of adverse outcomes in at least a subset of the frail patients. Due to the lack of concrete evidence from Danish intermediate care context, which remains largely under-studied, verifying such speculations will require further investigation. However, we can refer to other implementations of transitional care models in other countries to infer the possibility of successfully managing and stabilizing frail patients and preventing early hospitalizations. For instance, many large cohort studies have reported higher short-term readmission rates after discharge from hospitals in patients with dementia [46, 47]. In contrast, a study on post-acute care facilities in the United States reported reduced risk of readmission in patients with low (versus high) cognitive performance [24], and another Australian study did not find a significant association between cognitive impairment and early readmission in geriatric rehabilitation patients [26]. Similarly, several studies have identified a history of stroke as a marker of higher readmission risk in general hospital populations [18, 42], but there is evidence that stroke and cerebrovascular disease survivors admitted to supporting care settings have no increased risk or even have fewer readmissions [25, 48], possibly due to better post-acute management.

The identified risk factors in our study point to both disease-specific and general care gaps that may inform risk stratification as a prerequisite for targeted interventions to preempt early hospitalization among high-risk TS patients. Flagging patients with a higher count of significant risk factors at key transition points—ideally at hospital discharge or upon arrival at TS—facilitates resource allocation and implementation of interventions. Our findings suggest that developing risk scores patterned by male sex, higher multimorbidity, recent hospitalization, and markers of intensive prior health care use (polypharmacy, repeated hospitalizations, surgical procedures) could be a valuable approach to filter targets of intensified transitional support.

Despite feasibility of risk stratification, implementing appropriate interventions may be a challenging task. Previous research has shown that most interventions aimed at reducing hospital readmissions did not affect readmission rates [49–51]. A systematic review on the impact of transitional care interventions on hospital readmission in older medical patients reported that most successful interventions were of high intensity, lasted at least one month, and specifically targeted patients at risk [6]. Some disease-specific interventions have been successful in reducing early readmissions, e.g., for patients with heart failure [52], chronic pulmonary disease [53], or kidney disease [54]. However, evidence from a nationwide

cohort study on older acutely admitted patients in Denmark revealed that roughly 73% of readmitted patients returned to hospital for a different reason than the previous diagnosis [21]. Therefore, targeting a single disease may not be an effective approach on its own. Additionally, given the low specialization level of Danish TS facilities, implementing interventions for every disease-specific risk factor may not be practical. Meanwhile, holistic interventions could mitigate the cumulative risk from multimorbidity, and healthcare utilization factors. For instance, medication review and deprescribing have shown reductions in readmission rates among older adults [55], and multidisciplinary geriatric assessment teams in transitional care can reduce subsequent acute care use [5, 56]. Notably, evidence from a single Danish TS facility shows that follow-up visits by an outgoing multidisciplinary geriatric team significantly reduced 30-day readmission [56].

A major strength of our analysis was the use of competing risk framework. Given that the 30-day mortality rate in our population was not negligible when compared with the 30-day hospitalization rate (8% versus 26%), we employed competing risk models to account for the outcome of death preventing the occurrence of hospitalizations. Many studies omit competing risk analyses out of convenience or convention. However, violating the assumption of noninformative censoring, i.e., treating death as censoring, can lead to biased results by overestimating the risk of the main event of interest, especially in older, multimorbid populations [36, 57]. A review of 100 studies published in prominent medical journals concluded that 46% were susceptible to competing risk bias [58], highlighting the importance of using competing risk models for accurate risk estimation. Furthermore, our use of additive competing risks regression modeling to directly estimate the absolute risk ratios improves the interpretability of results compared to other methods reporting associations on the hazard scale. In terms of discriminant ability, our chosen risk regression model outperformed the widely-used Fine-Gray model, highlighting the strength of the chosen methodology.

The results of this study must be viewed in light of its limitations. Several important predictors identified in prior studies were not evaluated in our analysis due to data limitations. Functional ability, cognitive status, living alone, social support, and other socioeconomic factors were not captured, though evidence suggests each may affect patient outcomes [59–62]. Also, the reasons for recent hospitalization (primary diagnoses) before TS admission were sparsely distributed as previously reported [13], and therefore, we did not evaluate their potentially important role in readmissions. The only indicators we extracted from recent hospitalization episodes were primary diagnosis of fall injuries, surgical

interventions, and length of stay at hospital. Furthermore, TS facility quality indicators were not investigated in this study. As a decentralized care setting, TS facilities vary in size, staffing mix, and the type of services they offer [12] and there is evidence that patient characteristics and trajectories vary across municipalities [13]. Another limitation of this study is the focus on all-cause hospitalizations without considering whether they were unplanned or preventable. All of these limitations are known to negatively affect the performance of most hospital readmission risk prediction models, resulting in relatively poor discriminant ability [63, 64] as observed in our study. Finally, despite using a large cohort across multiple Danish municipalities and regions, our results may not be generalizable to other intermediate care settings due to the diverse and fragmented implementation of intermediate care globally [5].

## Conclusion

Early (re)hospitalization after admission to Danish municipal temporary stay facilities was common (26.1% within 30 days) and occurred alongside substantial early mortality (7.6%), underscoring the need for robust transitional care in this setting. Risk was patterned by male sex, higher multimorbidity, recent hospitalization, and markers of intensive prior healthcare use (polypharmacy, repeated admissions, surgical procedures). In contrast, advancing age, dementia, and prior stroke/TIA were associated with lower risk. In recently hospitalized patients, a fall-injury index diagnosis lowered 30-day risk, while recent surgery and hospital stays > 14 days increased it. Although discrimination was modest (c-index ~0.62), the identified predictors can support risk stratification to prioritize higher-intensity transitional support (e.g., medication review/deprescribing, multidisciplinary geriatric outreach) for those most likely to return to hospital. Future research should integrate functional status, cognitive and social determinants, and TS facility characteristics, and distinguish unplanned or potentially preventable readmissions to sharpen prediction and guide targeted, scalable interventions in TS.

## Abbreviations

|      |  |
|------|--|
| TS   | Temporary stay   |
| CPR  | Central Person Register  |
| ICD  | International classification of diseases                                   |
| DNPR | Danish National Patient Registry   |
| SKS  | Sundhedsvæsenets klassifikationssystem (Health care classification system) |
| ATC  | Anatomical therapeutic chemical classification                             |
| CIF  | Cumulative incidence function  |
| CI   | Confidence interval  |
| ARR  | Absolute risk ratio  |
| uARR | Unadjusted absolute risk ratio   |
| aARR | Adjusted absolute risk ratio   |
| IFPW | Inverse failure probability weighting                                      |
| IQR  | Interquartile range  |
| TIA  | Transient ischaemic attack   |

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12913-026-14045-9>.

Supplementary Material 1

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Not applicable.

## Author contributions

MR, KK, and KE conceptualized and designed the study. MR performed the statistical analysis and wrote the manuscript. MR and AP interpreted the results. KK, KE, and AP have read and commented on the manuscript. All authors have read and approved the final version of the manuscript for submission.

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## Data availability

Danish legislation does not allow individual-level data to be publicly available. Anonymized data can be accessed by authorized researchers after application to Forskeservice at the Danish Health Data Authority. MR had full access to the data. Coding scripts for the analysis are available upon request.

## Declarations

### Ethics approval and consent to participate

This research project has been conducted in accordance with the principles of the Helsinki Declaration and further adheres to the legal requirements of the study country. This study was register-based, only anonymized data was used, data is presented in aggregate and anonymous form, and study participants were not contacted nor required any active participation. According to Danish law, approval from an ethics committee and informed consent to participate are not required for register-based studies (section 14.2 of the Act on Research Ethics Review of Health Research Projects and section 10 of the Data Protection Act). In terms of data protection, the study was registered at the University of Southern Denmark inventory (record no. 11.436).

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

### Author details

<sup>1</sup>Department of Engineering Technology and Didactics, Technical University of Denmark, Ballerup, Denmark

<sup>2</sup>Department of Public Health, University of Southern Denmark, Odense, Denmark

<sup>3</sup>Hospital Pharmacy Funen, Odense University Hospital, Odense, Denmark

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