RESEARCH REPORT

Recurrent risk of hospitalization among older people with problematic alcohol use: a multiple failure-time analysis with a discontinuous risk model

Wossenseged Birhane Jemberie1,2,3 | Mojgan Padyab1,2 | Dennis McCarty4 | Lena M. Lundgren1,5

1Department of Social Work, Umeå University, Umeå, Sweden
2Centre for Demographic and Ageing Research (CEDAR), Umeå University, Umeå, Sweden
3The Swedish National Graduate School on Aging and Health (SWEAH), Faculty of Medicine, Lund University, Lund, Sweden
4Oregon Health and Science University-Portland State University, School of Public Health, Portland, OR, USA
5Cross-National Behavioral Health Laboratory, Graduate School of Social Work, University of Denver, Denver, CO, USA

Correspondence
Wossenseged Birhane Jemberie, Department of Social Work, Umeå University, 901 87, Umeå, Sweden. Email: wossenseged.jemberie@umu.se

Abstract

Background and aims: Older people with problematic alcohol use vary in psychosocial functioning, age of onset for problem drinking and use of other drugs. The study measured the differential risks of all-cause, alcohol-, polydrug- and psychiatric-related repeated hospitalizations among older people with problematic alcohol use.

Design: A linked register-based cohort study with discontinuous multiple-failure (time-to-repeated-event) data. Hospitalization and mortality were considered as failure.

Setting: Sweden, March 2003–November 2017, using data from the Addiction Severity Index (ASI) register linked to National Inpatient Register and the Swedish cause of death register.

Participants: Participants aged 50 years and older (n = 1741; 28.2% women), with one or more alcohol problem days in the 30 days before an ASI assessment.

Measurements: Five mutually exclusive latent classes of problematic alcohol use, identified with 11 ASI items, were the independent variables: ‘late onset with fewer consequences (LO:FC; reference group)’; ‘early onset/prevalent multi-dimensional problems (EO:MD)’; ‘late onset with co-occurring anxiety and depression (LO:AD)’; ‘early onset with co-occurring psychiatric problems (EO:PP)’; and ‘early onset with major alcohol problem (EO:AP)’. Covariates included socio-demographic characteristics, previous hospitalization and Elixhauser comorbidity index. Outcome measurements included recurrent hospitalization and/or mortality due to: (a) all-cause, (b) alcohol-related disorders and diseases (c) polydrug use and (d) other psychiatric disorders.

Findings: During the study period, more than 75% were hospitalized at least once or died. 57.3% were hospitalized with alcohol-related, 8.5% with polydrug use and 18.5% with psychiatric-related diagnoses. Compared with LO:FC, EO:PP had higher risk for all-cause [adjusted hazard ratio (aHR) = 1.27, 95% confidence interval (CI) = 1.02–1.59] and alcohol-related (aHR = 1.34, 95% CI = 1.02–1.75) hospitalizations. Adjusted risks for polydrug-related hospitalization were 2.55, 95% CI = 1.04–6.27 for EO:MD and 2.62, 95% CI = 1.07–6.40 for EO:PP. Adjusted risk for psychiatric-related hospitalization was higher for LO:AD (aHR = 1.78, 95% CI = 1.16–2.73 and EO:PP (aHR = 2.03, 95% CI = 1.22–3.38).
INTRODUCTION

Problematic alcohol use is prevalent among older people, reaching 30% in some countries [1–4]. A quarter of addiction service users are older people and alcohol is the major substance of use [5]. Harms, such as falling, delirium, severe drug interaction, frailty, cognitive deterioration and death, are linked to alcohol use [6–11].

Physical and psychiatric comorbidities are also common among older people with problematic drinking [4,12–14]. Population-based epidemiological studies suggest that older people with a history of psychiatric disorders are up to four times more likely to have an alcohol use disorder [15].

Problematic alcohol use is linked to increased health-care utilization among older people. In Denmark, older people with alcohol use disorder had elevated rates of somatic health-care utilization prior to their diagnosis [16]. The number of older people hospitalized with alcohol- and other drug-related conditions has increased [17–19], and some required post-discharge care in a specialized setting [20]. Swedish data suggest that approximately 66% of alcohol-related hospitalizations are recorded among people aged 50 years and older, and approximately 700 per 100 000 people aged 60 years and older die due to alcohol-related causes [21]. It is, however, relatively unknown if the risk of substance use disorder and/or psychiatric-related hospitalization varies among older people with varying socio-demographic and clinical profiles.

The Swedish addiction service is decentralized and publicly funded. Social services within municipalities provide most addiction treatment services. The health-care services at regional levels (administrative unit higher than municipalities) deal with medication for substance use disorders and with medical care for emergency and chronic physical and psychiatric comorbidities. Due to their delivery of addiction and old-age care, social services are more likely to reach older people with an alcohol problem. Official open-comparison data from Kolada, the Swedish database for municipal and regional benchmarking, however, shows that almost 60% of the municipalities do not routinely coordinate old-age care and substance use services [22]. Additionally, more than 60% of the municipalities do not have joint agreements with regional entities to coordinate social services, primary care and specialty psychiatric care with substance use services [22]. As a result, many patients are not satisfied with the coordination within health and social services [23].

Studies using data from social services to investigate the characteristics and health outcomes for older addiction service users are scarce. A latent class analysis of Addiction Severity Index (ASI) data from social services examined heterogeneity among older people assessed for alcohol use severity and identified five classes (subtypes) of problematic alcohol use which varied in psychosocial functioning, age and gender composition, age of onset for problem drinking and use of other drugs [24]. See the Methods and Results sections for short summaries of the classes. This study estimates the risk of all-cause, alcohol use-, polydrug use- and psychiatric-related repeated hospital admissions among older people with problematic alcohol use after their initial assessment at social services and the associations with the five categories of service users.

METHODS

Study setting

Study population

The analysis included adults aged 50 years or older, who were assessed for substance use severity between 4 March 2003 and 29 May 2017, in 65 Swedish municipalities, and reported one or more days with an alcohol-related problem (i.e. craving, withdrawal symptom, disturbing effect of intoxication, wanting to stop and not being able to do so) in the 30 days prior to the baseline ASI assessment. Hospitalization data for the study population were available for the period between 16 October 2000 and 11 November 2017. Mortality data were available from the date the first death was recorded (9 August 2004) to the end of the study period (11 November 2017). The municipalities consented to the inclusion of their data in the analyses conducted as part of the STANCE project. The Ethical Review Authority in Umeå, Sweden reviewed and approved the study (DNR: 2016/504–31; amendment 2020–06233). The authority waived the need for patient consent.

Study design

We employed a retrospective cohort design with routinely collected data from the ASI databases maintained by Swedish municipalities and linked to the National Inpatient Register (IPR) and the Swedish cause of death register. The analysis used full hospitalization and mortality data during the study period, resulting in a
multiple-failure survival data set. Five events were recorded by the end of the study period: (1) hospitalized once and survived (single failure), (2) no hospitalization and died (single failure), (3) hospitalized two or more times and survived (multiple failure), (4) hospitalized one or more times and died (multiple failure) and (5) no hospitalization and survived (censored). An extract from the linked registers illustrates the survival data set; see Supporting information, Table S1.

ASI database

Currently, 90% of the Swedish municipalities use the ASI to evaluate problem severity and intervention needs among individuals aged 18 years and older. Social workers with ASI training conducted the assessments. Studies have reported the validity and reliability of the original and the Swedish version of the ASI instrument [25,26].

National inpatient register

The National Board of Health and Welfare (NBHW) administers register data on all physical and psychiatric-related hospital discharges. Since 1997, the International Statistical Classification of Diseases, 10th revision (ICD-10) diagnostic codes record principal and contributing diagnoses. The register has full coverage and strong validity [27].

Swedish cause of death register

The NBHW cause of death register contains data on underlying and contributing causes of deaths in Sweden, with almost 99% of all deaths reported and a specific underlying cause of death recorded for 96% of individuals in the register [28].

Data linkage

The unique personal identity number (PIN), assigned at birth or on immigration to Sweden, linked the ASI assessment data to the inpatient and cause of death registers. Data were pseudonymized and the PIN was masked with a unique serial number by responsible authorities before data were released for the analysis. Statistics Sweden maintains the pseudonymization key.

Outcome measures

We extracted information on outcome variables from the Swedish inpatient register and cause of death register, and investigated four adverse events:

1. All-cause hospitalization: a composite measure of all-cause hospitalization and mortality. All episodes of hospitalization and mortality data were considered failure events.
2. Alcohol-related hospitalization: a composite measure of hospitalization and death due to alcohol-related disorders and diseases (ARDDS). Principal or contributing alcohol-related diagnoses at hospital admission or death were included in the analysis. The ICD-10 codes were based on the NBHW guideline for coding ARDDS [29,30]; see Appendix S1, Supporting information, Table S2.
3. Polydrug use disorder-related hospitalization: a composite measure of hospitalization and death related to polydrug use disorders. The measure included ARDDS diagnoses and other drug use disorders (ICD-10 codes F11–F19) as principal or contributing causes for hospitalization or death.
4. Psychiatric-related hospitalization: psychiatric diagnoses as principal and contributing causes of hospitalization. Hospitalization with psychiatric diagnoses: F00–F09; F20–F29; F30–F39; F40–F48; F60–F62; F63–F69; F90–F99.

Exposure measures

Variables were obtained from the ASI database and the national inpatient register. The independent variable was membership in one of the five multi-dimensional subtypes/classes of problematic alcohol use obtained through a latent class analysis. The subtypes were: late onset/functional with fewer consequences (LO:FC); the reference category; early onset/multi-dimensional problems (EO:MD); late onset with co-occurring anxiety and depression (LO:AD); early onset with co-occurring psychiatric problems (EO:PP); early onset/major alcohol problem (EO:AP). The 11 indicators used to identify the five classes were: age of onset of regular drinking, age of onset of heavy drinking, life-time history of polydrug use, life-time history of sedatives, recent drug-related problem, life-time history of depression, life-time history of anxiety, life-time history of trouble controlling violent behaviour, recent physical health problems, life-time history of adult criminal justice involvement and recent history of conflict with family members. The characteristics of the study population, the classification process, the identified subtypes and their concurrent validity have been described elsewhere [24]. We also provide a short summary of the results from the analysis in the Results section.

Covariates

Covariates were included based on previous studies on predictors of repeated medical, substance use and psychiatric-related hospital admissions [31–34]. See Table 1 for the descriptive statistics for all covariates included in the analysis.

Socio-demographic characteristics were extracted from the baseline ASI assessment and included age, sex, migration status, ASI composite score for legal problems, marital status, usual employment
# Table 1: Descriptive statistics for exposure variables included in the analysis

| Variable                                         | N = 1741 |
|--------------------------------------------------|----------|
| **Subtypes, n (%)**                              |          |
| Late onset/functional with fewer consequences    | 512 (29.4%) |
| Early onset/multi-dimensional problems           | 183 (10.5%) |
| Late onset with co-occurring anxiety and depression| 469 (26.9%) |
| Early onset with co-occurring psychiatric problems| 239 (13.7%) |
| Early onset/major alcohol problem                | 338 (19.4%) |
| **Physical comorbidity, n (%)**                  |          |
| 0 physical comorbidity                           | 1035 (59.4%) |
| 1 physical comorbidity                           | 357 (20.5%) |
| 2 or more physical comorbidities                | 349 (20.0%) |
| **Past year hospitalization, median (IQR)**      | 1.0 (0, 2) |
| Past year hospitalization: ARDDS, median (IQR)  | 0 (0, 2) |
| Past year hospitalization: polydrug, median (IQR)| 0 (0, 0) |
| Past year hospitalization: psychiatric No ARDDS, median (IQR) | 0 (0, 0) |
| Past year hospitalization: dual psychiatric and ARDDS, median (IQR) | 0 (0, 0) |
| **Age group, n (%), years**                      |          |
| 50–64                                            | 1538 (88.3%) |
| 65 or older                                      | 203 (11.7%) |
| **Sex, n (%)**                                   |          |
| Male                                             | 1250 (71.8%) |
| Female                                           | 491 (28.2%) |
| **Marital status, n (%)**                        |          |
| Married                                          | 308 (17.7%) |
| Civil partnership                                | 202 (11.6%) |
| Separated/widowed                                | 1106 (63.5%) |
| Single, never married/cohabited                  | 124 (7.1%) |
| **Migration status, n (%)**                      |          |
| Born in Sweden: parents born in Sweden           | 1348 (77.4%) |
| Born in Nordic countries outside Sweden          | 168 (9.6%) |
| Born outside Nordic countries                    | 66 (3.8%) |
| Born in Sweden with parents born in other Nordic countries | 99 (5.7%) |
| Born in Sweden with at least one parent born outside Nordic countries | 46 (2.6%) |
| **Usual employment pattern in the past 3 years, n (%)** |          |
| Full-/part-time employed                         | 719 (41.3%) |
| Unemployed/irregular/disability                  | 821 (47.2%) |
| Pension for retired                               | 167 (9.6%) |
| Study/conscripted/institutionalized              | 15 (0.9%) |
| **Education level, n (%)**                       |          |
| Less than 9 years                                 | 231 (13.3%) |
| Above 9 years but below 12 years                 | 784 (45.0%) |
| Finished 12 years                                | 212 (12.2%) |
| More than 12 years                               | 494 (28.4%) |
| **Residential town population size, n (%)**      |          |
| More than 100 000 people                         | 805 (46.2%) |
| Between 10 000 and 100 000                       | 778 (44.7%) |
| Fewer than 10 000                                 | 156 (9.0%) |

(Continues)
pattern in the past 3 years, education, residential town population size and housing status.

Other covariates included number of all-cause and cause specific hospital admissions (extracted from the inpatient register) during the 365 days prior to the ASI assessment. The analysis adjusted for other comorbidities using Quan and colleagues’ algorithm for Elixhauser’s comorbidity categories [35]. We excluded four comorbidity categories related to substance use disorders, psychosis and depression. The 27 modified physical comorbidity categories were sorted into three groups (0: comorbidity, 1: comorbidity and 2+: comorbidity groups). Supporting information, Table S3 lists the ICD-10 codes used to generate the comorbidity categories.

Statistical analysis

We applied the Andersen–Gill model, an extension of the traditional Cox regression model, for analyzing time-to-repeated-events [36,37]. Participants contributed person-time from the time they received an initial ASI assessment to the first episode of hospitalization or death. For recurrent episodes, the person-time included the time between consecutive episodes. Participants who were hospitalized were not considered at risk of a subsequent failure until their discharge, resulting in a discontinuous time interval. A robust estimate of covariance matrix account adjusted for intra-individual correlations between episodes [38]. We tested the proportional hazards assumption by assessing the relationship between the scaled Schoenfeld residuals against the log function of time. Covariates-adjusted hazard ratios (aHR) with 95% confidence intervals (CIs) examined the association between latent class membership and recurrent events. The regression models included individuals with complete data for all covariates. The incidence rates and the median survival times along with the 25th and 75th percentiles with respect to the four outcome measures were calculated for the five classes separately. The statistical analyses were conducted using Stata standard edition, version 15.1 [39].

Sensitivity analyses

We performed sensitivity analyses on the outcome variables (a) by excluding death events from the analyses for all-cause and ARDDS-related hospitalization episodes; and (b) by separating the psychiatric-related recurrent episodes into two subgroups. Psychiatric diagnoses in the presence of any ARDDS were labelled as dual diagnoses and those with no ARDDS as ‘primary psychiatric’. In the latter case, psychiatric hospitalization can be in the presence of diagnosis related to drugs other than alcohol. See Supporting information, Appendix A2 for the detailed sensitivity analysis.

Reporting method

We used the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guideline and its extension, RECORD (Reporting of Studies Conducted using Observational Routinely collected health data) guideline [40,41]. See Supporting information, Appendix S3 for the STROBE and RECORD statement checklists.

This analysis was not pre-registered on a publicly available platform, and results should be considered exploratory.

RESULTS

A latent class analysis (LCA) on 1747 individuals aged 50 years or older identified five mutually exclusive classes through 11 life-time and recent problem indicators from the ASI instrument. The individuals were assessed between 2003 and 2017 and reported one or more days with an alcohol-related problem in the 30 days prior to assessment. The best class solution was determined based on the Bayesian information criterion (BIC), Young–Lo–Mendell–Rubin (VLMR P-value) and the bootstrap likelihood ratio tests (BLRT P-value). The classification quality of the selected five-class solution was
supported by an entropy value of 0.81, average class membership probabilities ranging from 0.86 to 0.92 and the standardized residuals Z-score for 99.5% of the response patterns being below 3.00 (and none above 5.00). Finally, the stability of the classes was validated using a six-step random split-sample cross-validation procedure and the discriminative validity using Bonferroni-corrected multiple pairwise comparisons.

Table 2 provides the latent class indicator variables and their conditional probabilities. Table 3 summarizes the characteristics of the five classes. Supporting information, Table S4 shows the average class probabilities for most likely class memberships.

The current study linked the ASI data from the 1747 individuals to the national inpatient register and the cause of death register. After data linkage, six individuals were excluded due to missing data on date of admission or death. As a result, the final analysis included 1250 men and 491 women, aged 50 years or older, with alcohol-related problems (Figure 1).

Hospitalization and mortality

During the study period, 11 801 episodes of adverse events (11 455 hospital admissions and 346 deaths) were recorded for the study population. Approximately 70% of those events (8044 admissions and 115 deaths) were alcohol-related. Forty deaths occurred without a preceding hospitalization. Polydrug use disorder-related diagnoses were recorded in 2.5% of cases (288 admissions and four deaths).

Approximately 8% of hospital admissions during the study period were related to psychiatric diagnoses (455 dual diagnoses and 489 ‘primary psychiatric’ diagnoses).

More than 75% of older people assessed for substance use were hospitalized at least once or died during the study period. Approximately two-thirds (57.3%) were hospitalized once or more due to ARDDS, 8.5% due to polydrug use disorders and 18.5% due to psychiatric-related diagnoses. Figure 2 examines the frequency of adverse events and Figure 3 provides the percentage of individuals who experienced those events stratified according to the five classes of problematic alcohol use.

Table 4 displays the incidence rates (IR) with 95% CI, and median survival times along with 25th and 75th percentiles for the five classes of problematic alcohol use. The aHR for the outcome variables according to the five subtypes of problematic alcohol use and other covariates are given in Table 5.

**All-cause hospitalization**

The incidence rate for all-cause hospitalization and death in the cohort was 1626.25 per 1000 people per year with a median survival time of 137 days. When compared to the LO:FC subtype, patients in the EO:PP subtype had a 27% increase on the risk of a recurrent episode (aHR = 1.27; 95% CI = 1.02, 1.59). For other subtypes, after adjusting for covariates, the association between non-cause-specific recurrent adverse event and class membership was not statistically significant (see Table 5). The number of hospital admissions in the year before ASI assessment, criminal justice involvement, not being married, unemployment, having a higher education level and having a physical comorbidity were all associated with increased risk of repeated hospital admission. Women had a 15% lower risk for recurrent events compared to men (aHR = 0.85; 95% CI = 0.73, 0.99) (see Table 5).

**ARDDS-related hospitalization**

During the study period, the incidence rate of alcohol-related recurrent hospitalizations and mortality for the study cohort was 1124.36 per 1000 people per year, with half experiencing the first event

| Class indicator variables (based on ASI) | LO:FC | EO:MD | LO:AD | EO:PP | EO:AP |
|-----------------------------------------|-------|-------|-------|-------|-------|
| Early onset age of regular drinking     | 0.12  | 0.86  | 0.13  | 1.0   | 0.93  |
| Early onset age of heavy drinking       | 0.07  | 0.86  | 0.13  | 0.98  | 1.0   |
| Presence of recent conflict with family | 0.17  | 0.24  | 0.27  | 0.22  | 0.14  |
| History of criminal charge or arrest as adult | 0.20 | 0.93  | 0.22  | 0.48  | 0.39  |
| History of polydrug use                 | 0.01  | 0.86  | 0.04  | 0.08  | 0.06  |
| History of sedative use                 | 0.07  | 0.59  | 0.30  | 0.37  | 0.15  |
| Presence of recent drug-related problem days | 0.01 | 0.51  | 0.02  | 0.07  | 0.02  |
| History of depression                   | 0.19  | 0.58  | 0.92  | 1.0   | 0.16  |
| History of anxiety                      | 0.18  | 0.64  | 0.92  | 0.94  | 0.21  |
| History of impulsive behaviour          | 0.09  | 0.56  | 0.17  | 0.37  | 0.11  |
| Presence of recent somatic health problems | 0.49| 0.74  | 0.69  | 0.69  | 0.53  |

ASI, Addiction Severity Index; LO:FC, late onset/functional with fewer consequences; EO:MD, early onset/multi-dimensional problems; LO:AD, late onset with co-occurring anxiety and depression; EO:PP, early onset with co-occurring psychiatric problems; EO:AP, early onset/major alcohol problem.
TABLE 3 Short summary of characteristics for the five subtypes of problematic alcohol use among Swedish older people

‘Late onset/functional with fewer consequences’ (LO:FC; n = 512, women = 133)
- Late onset of regular (aged 41 years) and heavy drinking (aged 47 years)
- 40% were married or living with partner
- Low number of problem days with loneliness
- Highest labour participation
- Oldest group: 20% were aged 65 years or older

‘Early onset/multi-dimensional problems’ (EO:MD; n = 183, women = 31)
- Early onset of regular (aged 20 years) and heavy drinking (aged 22 years)
- Concurrent narcotic, legal, employment and health (both physical and psychiatric) problems
- Prevalent paternal alcohol problem (60%) and history of trauma
- Only 17% were married or living with partner
- Youngest age group (mean age = 54 years)

‘Late onset with co-occurring anxiety and depression’ (LO:AD; n = 470, women = 221)
- Late onset of regular (aged 40 years) and heavy drinking (aged 45 years)
- Prevalent life-time and current co-occurring anxiety and depression (92%)
- 47% were women
- Very high number of problem days with loneliness
- History of emotional, sexual and physical abuse

‘Early onset with co-occurring psychiatric problems’ (EO:PP; n = 239, women = 64)
- Early onset of regular (aged 20 years) and heavy drinking (aged 21 years)
- Elevated proportions of life-time and current anxiety and depression
- High prevalence of life-time suicidal ideation (64%) and attempt (42%)
- Moderate endorsement of criminality indicator
- Elevated levels of charges for disorderly conduct
- Low proportion (16%) of married or living with partner

‘Early onset/major alcohol problem’ (EO:AP; n = 340, women = 43)
- Early onset of regular (aged 21 years) and heavy drinking (aged 23 years)
- Higher incidence of alcohol delirium tremens and episodes of inpatient care for alcohol treatment

Polydrug use disorder-related hospitalization

For polydrug-related recurrent events, the median survival time for the study cohort was 12.17 years (4445 days) and the incidence rate was 40.24 per 1000 people per year. The median survival time was 6.1 years (2227 days) for the class EO:MD and the incidence rate was 128.81 per 1000 people per year (Table 4). Of the nine deaths attributed to drugs other than alcohol, six were recorded among this class. The EO:MD class was also associated with 155% increase of recurrent events related to polydrug use disorder (aHR = 2.55; 95% CI = 1.04, 6.27). Class membership in the EO:PP subtype was associated with increased risk for polydrug use-related outcomes (aHR = 2.62; 95% CI = 1.07, 6.40) (Table 5). Increased risk for such adverse events was also associated with the covariates: previous polydrug use-related hospital admission, criminal justice system involvement, unemployment and physical comorbidity (see Table 5).

Psychiatric-related hospitalization

The rate of recurrent psychiatric admissions among the cohort was 130.09 per 1000 people per year. The median survival time was 5.54 years (2023 days). The LO:FC and EO:AP had the lowest incidence rates (Table 4). After adjusting for covariates, class membership to LO:AD and EO:PP were associated with 78% (aHR = 1.78; 95% CI = 1.16, 2.73) and 103% (aHR = 2.03; 95% CI = 1.22, 3.38) increases, respectively, in recurrent psychiatric re-admission post-baseline assessment. Furthermore, previous admission-related psychiatric diagnoses, unemployment, higher education level and physical comorbidity were associated with an increased risk of recurrent psychiatric admission (see Table 5).

Sensitivity analyses

The results for all-cause and alcohol-related recurrent hospitalization did not change when we repeated the analyses after removing death events (see Supporting information, Appendix S2). For psychiatric-related admissions with no concurrent alcohol-related diagnoses, class membership to EO:MD was associated with a 121% increase in risk of recurrent hospitalization (aHR = 2.21; 95% CI = 1.06, 4.58). For dual diagnoses outcome, class membership to LO:AD was associated with increased risk for recurrent hospitalization (aHR = 1.81; 95% CI = 1.03, 3.19). The hazard ratio for EO:PP was 1.88 (95% CI = 0.99, 3.58) (Supporting information, Table S5).
DISCUSSION

The analysis investigated the risk of all-cause, alcohol use-, polydrug use- and psychiatric disorders-related recurrent hospitalization among 1741 older people with problematic alcohol use after their index ASI assessment. During the study period, 11,455 hospital admissions and 346 deaths were recorded. Approximately three of four were hospitalized at least once during the study period. Approximately 70% of hospitalizations and 33% of deaths in the cohort were related to alcohol-related disorders and diseases. Furthermore, 18.5% of the cohort were hospitalized at least once with psychiatric-related disorders and 8.5% with polydrug use disorders. More than 10% (n = 183) were hospitalized at least once with dual alcohol use and psychiatric disorders. Previous cross-sectional analysis of older samples from emergency departments, medical and psychiatric inpatient stays reported a high prevalence of alcohol use disorder [15,42–45]. Our study found an increased risk of hospitalization and mortality among older addiction service users in a
14-year study period. The risk, moreover, varied among previously identified subgroups of service users [24]. The analyses underscored the heterogeneity of older addiction service users with respect to disease comorbidity and treatment need throughout the care continuum, even in the presence of similar alcohol-related problems.

The risk for recurrent hospitalization and mortality with alcohol-related disorders and diseases (ARDDS) was higher for EO:PP when
TABLE 4  Incidence rates (with 95% CIs) and median survival time (with 25th and 75th percentiles) for outcome variables according to the five subtypes of problematic alcohol use

|                      | LO:FC (n = 512) | EO:MD (n = 183) | LO:AD (n = 469) | EO:PP (n = 239) | EO:AP (n = 338) |
|----------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| **All-cause**        |                 |                 |                 |                 |                 |
| IR (95% CI)          | 1543.57 (1490.88–1598.12) | 1545.68 (1463.03–1633.00) | 1632.43 (1575.25–1691.69) | 2105.88 (2019.52–2195.93) | 1441.34 (1381.44–1503.84) |
| Median survival time (IQR) | 157 (63–293) | 162 (56–309) | 125 (51–271) | 119 (38–251) | 138 (49–300) |
| **ARDDS**           |                 |                 |                 |                 |                 |
| IR (95% CI)          | 1104.97 (1060.54–1151.27) | 815.37 (755.95–879.46) | 1096.39 (1049.71–1145.15) | 1581.09 (1506.50–1659.37) | 1037.06 (986.44–1090.28) |
| Median survival time (IQR) | 200 (76–388) | 272 (119–627) | 179 (64–382) | 140 (55–318) | 171 (63–399) |
| **Polydrug**         |                 |                 |                 |                 |                 |
| IR (95% CI)          | 15.51 (10.97–21.93) | 128.81 (106.48–155.82) | 25.94 (19.55–34.42) | 62.47 (48.99–79.67) | 27.72 (20.41–37.64) |
| Median survival time (IQR) | 4592 (3621, RC) | 2227 (921–3186) | RC (3505, RC) | RC (1398, RC) | RC (3695, RC) |
| **Psych**           |                 |                 |                 |                 |                 |
| IR (95% CI)          | 75.60 (64.62–88.45) | 110.58 (90.04–135.80) | 190.21 (171.34–211.15) | 239.33 (211.37–270.98) | 64.90 (53.13–79.27) |
| Median survival time (IQR) | 3155 (1654, RC) | 2278 (843–4205) | 1316 (454–2729) | 1207 (533–2065) | 3594 (1687–4410) |

LO:FC, late onset/functional with fewer consequences; EO:MD, early onset/multi-dimensional problems; LO:AD, late onset with co-occurring anxiety and depression; EO:PP, early onset with co-occurring psychiatric problems; EO:AP, early onset/major alcohol problem; All-cause, all-cause hospitalization; IR, incidence rate; 95% CI, 95% confidence interval; IQR, interquartile range; ARDDS, alcohol-related disorders and diseases; Polydrug, polydrug use disorder-related hospitalization; RC, right-censored; Psych, psychiatric-related hospitalization.
### TABLE 5  Covariate-adjusted hazard ratios and 95% confidence intervals (CI) for recurrent hospitalizations due to all-cause, alcohol-related, polydrug use and psychiatric disorders and diseases

| Subtypes                                      | All-cause | ARDDS | Polydrug | Psych |
|-----------------------------------------------|-----------|-------|----------|-------|
| **Late onset/functional with fewer consequences** | HR (95% CI) | Ref    | Ref      | Ref   |
| Early onset/multi-dimensional problems        | 0.88 (0.69–1.11) | 0.68 (0.51–0.89) | 2.55 (1.04–6.27) | 1.30 (0.71–2.39) |
| Late onset with co-occurring anxiety and depression | 0.99 (0.83–1.20) | 0.93 (0.73–1.17) | 1.27 (0.54–2.98) | 1.78 (1.16–2.73) |
| Early onset with co-occurring psychiatric problems | 1.27 (1.02–1.59) | 1.34 (1.02–1.75) | 2.62 (1.07–6.40) | 2.03 (1.22–3.38) |
| Early onset/major alcohol problem             | 0.88 (0.73–1.06) | 0.87 (0.69–1.09) | 1.43 (0.60–3.39) | 0.81 (0.51–1.29) |
| **Physical comorbidity**                      |           |       |          |       |
| 0 physical comorbidity                        | Ref       | Ref   | Ref      | Ref   |
| 1 physical comorbidity                        | 2.22 (1.85–2.65) | 2.09 (1.70–2.57) | 1.67 (0.98–2.87) | 2.05 (1.38–3.05) |
| 2 or more physical comorbidities             | 2.68 (2.28–3.14) | 2.20 (1.80–2.69) | 4.27 (2.81–6.49) | 2.31 (1.54–3.45) |
| Past year hospitalization                     | 1.11 (1.09–1.13) | –      | –        | –     |
| Past year hospitalization: ARDDS              | –         | 1.14 (1.12–1.16) | –        | –     |
| Past year hospitalization: polydrug           | –         | –      | 1.90 (1.40–2.58) | –     |
| Past year hospitalization: psychiatric no ARDDS | –       | –      | –        | 2.09 (1.59–2.75) |
| Past year hospitalization: dual psychiatric and ARDDS | – | – | – | 1.56 (1.41–1.73) |
| Age group (years)                             |           |       |          |       |
| 50–64                                         | Ref       | Ref   | Ref      | Ref   |
| 65 or older                                   | 0.99 (0.68–1.44) | 0.86 (0.51–1.44) | 0.78 (0.35–1.73) | 1.42 (0.77–2.61) |
| **Sex**                                       |           |       |          |       |
| Male                                          | Ref       | Ref   | Ref      | Ref   |
| Female                                        | 0.85 (0.73–0.99) | 0.80 (0.65–0.98) | 0.86 (0.51–1.44) | 0.82 (0.57–1.18) |
| **Marital status**                            |           |       |          |       |
| Married                                       | Ref       | Ref   | Ref      | Ref   |
| Civil partnership                             | 1.10 (0.87–1.40) | 1.16 (0.86–1.58) | 1.28 (0.48–3.42) | 0.77 (0.45–1.33) |
| Separated/widowed                             | 1.29 (1.07–1.56) | 1.42 (1.11–1.82) | 2.42 (0.99–5.91) | 1.18 (0.77–1.80) |
| Single, never married/cohabited               | 1.46 (1.12–1.90) | 1.63 (1.17–2.27) | 1.44 (0.48–4.28) | 1.98 (0.92–4.25) |
| Migration status                              |           |       |          |       |
| Born in Sweden: parents born in Sweden         | Ref       | Ref   | Ref      | Ref   |
| Born in Nordic countries outside Sweden        | 1.13 (0.90–1.41) | 1.17 (0.89–1.54) | 1.64 (1.02–2.65) | 1.02 (0.63–1.65) |
| Born outside Nordic countries                  | 1.08 (0.70–1.66) | 1.05 (0.59–1.87) | 0.36 (0.08–1.56) | 0.87 (0.45–1.66) |
| Born in Sweden with parents born in other Nordic countries | 0.92 (0.73–1.15) | 0.86 (0.63–1.16) | 1.33 (0.66–2.68) | 0.68 (0.36–1.29) |
| Born in Sweden with at least one parent born outside Nordic countries | 0.94 (0.65–1.34) | 0.95 (0.59–1.54) | 1.05 (0.38–2.90) | 0.34 (0.09–1.29) |
| Usual employment pattern, past 3 years         |           |       |          |       |
| Full/part time employed                       | Ref       | Ref   | Ref      | Ref   |
| Unemployed/irregular/disability               | 1.22 (1.05–1.42) | 1.15 (0.95–1.38) | 2.31 (1.36–3.91) | 2.18 (1.54–3.08) |
| Pension for retired                           | 1.07 (0.70–1.63) | 0.99 (0.56–1.76) | 1.61 (0.63–4.11) | 1.00 (0.50–2.00) |
| Study/conscripted/institutionalized           | 0.39 (0.18–0.82) | 0.26 (0.10–0.68) | 1.04 (0.27–3.95) | 0.89 (0.29–2.78) |
| Education level                               |           |       |          |       |
| Less than 9 years                             | Ref       | Ref   | Ref      | Ref   |
| Above 9 years but below 12 years              | 1.20 (0.97–1.48) | 1.48 (1.10–2.00) | 1.12 (0.72–1.75) | 1.51 (0.96–2.36) |
| Finished 12 years                             | 1.08 (0.81–1.44) | 1.31 (0.91–1.88) | 1.12 (0.57–2.20) | 2.18 (1.13–4.22) |
| More than 12 years                            | 1.45 (1.14–1.86) | 1.73 (1.24–2.41) | 1.09 (0.60–1.96) | 2.54 (1.60–4.02) |

(Continues)
TABLE 5 (Continued)

|                          | All-cause | ARDDS | Polydrug | Psych |
|--------------------------|----------|-------|----------|-------|
| Residential town population size |          |       |          |       |
| More than 100 000 people  | Ref      | Ref   | Ref      | Ref   |
| Between 10 000 and 100 000| 0.92 (0.80–1.07) | 0.88 (0.74–1.05) | 1.02 (0.70–1.50) | 1.02 (0.71–1.46) |
| Fewer than 10 000        | 0.88 (0.71–1.10) | 0.84 (0.62–1.13) | 1.09 (0.55–2.18) | 1.43 (0.87–2.34) |
| Accommodation status     |          |       |          |       |
| Own or housing with own contract | Ref      | Ref   | Ref      | Ref   |
| Housing with second-hand contract | 0.82 (0.54–1.26) | 0.77 (0.50–1.19) | 2.10 (1.08–4.09) | 0.55 (0.31–0.96) |
| Living in parents’ home  | 1.01 (0.77–1.33) | 1.08 (0.79–1.48) | 0.54 (0.27–1.09) | 0.18 (0.08–0.40) |
| Ordinary housing provided by social services | 0.75 (0.53–1.04) | 0.57 (0.39–0.83) | 0.24 (0.03–1.75) | 0.39 (0.14–1.08) |
| Housing with special services in accordance with Social Service Act | 0.70 (0.46–1.07) | 0.75 (0.46–1.23) | 1.65 (0.96–2.81) | 0.55 (0.24–1.26) |
| Hotel                    | 0.84 (0.29–2.40) | 1.11 (0.36–3.38) | 0.00 (NA – NA) | 0.32 (0.03–2.88) |
| Homeless                 | 1.15 (0.85–1.56) | 1.17 (0.82–1.67) | 0.78 (0.40–1.51) | 0.67 (0.36–1.23) |
| Other                    | 0.75 (0.49–1.14) | 0.78 (0.47–1.28) | 0.78 (0.37–1.64) | 0.55 (0.28–1.11) |
| ASI legal composite score| 1.83 (1.15–2.91) | 1.64 (0.91–2.97) | 4.12 (1.31–12.98) | 0.79 (0.26–2.47) |

All-cause, all-cause hospitalization; ARDDS, alcohol-related disorders and diseases; Polydrug, polydrug use disorder-related hospitalization; Psych, psychiatric-related hospitalization; HR, hazard ratio; Ref, reference; ASI, Addiction Severity Index.

Note: Estimates of associations are robust HRs with 95% CIs, representing risks of recurrent failure event (outcome variables) NA, not available.

The higher risk of recurrent hospitalization for polydrug use disorder suggests a need for early assessment and intervention for the multi-dimensional substance use problem among older people. Social workers in Sweden use interviewer severity ratings (ISR) to rate the treatment/intervention needs of service users throughout ASI problem domains on a scale from 0 to 9. Within the EO:MD class, the median ISR for alcohol problem was 6 (a rating for ‘treatment necessary’) and the median ISR for drug problem was 4 (a rating for ‘some treatment indicated’). The median ISR for drug problem for the EO:PP was 0 at the index ASI assessment [24], while the present study showed the class had an adjusted hazard ratio of 2.62 for polydrug use-related recurrent hospitalization. Substance use disorders and related harms among older people are often underestimated [46,47], despite prevalent potential adverse polydrug interactions among older people [7]. Underestimation of substance use problems makes treatment and early intervention less accessible for older people [4].

Our study also suggested that the risk for comorbid psychiatric hospitalization was elevated for older addiction service users who belong to the EO:MD, LO:AD and EO:PP classes. The EO:MD and EO:PP class members had a greater risk for psychiatric-related recurrent hospital admissions without alcohol-related diagnoses. Due to prevalent drug use other than alcohol in the two classes, the psychiatric-related admission can also include drug-related diagnoses. Members of the LO:AD class had increased risk for psychiatric-related recurrent admissions both with (dual diagnoses) and without alcohol-related diagnoses. Elevated prevalence of lifetime and recent history of depression, anxiety, suicidal ideation, loneliness and trauma at baseline in these three classes was previously reported [24]. Members of LO:AD differed from EO:MD and EO:PP as they had late onset age of heavy drinking, more women (almost 50%) and little engagement in violent behaviour. The median ISR for psychiatric problem was 5 (‘some treatment indicated’) for all three classes, an indication for a lower intensity of treatment need [24].

The current study does not examine what type of interventions social services provided to older service users after the assessment for substance use disorders. Addiction services in Sweden use the ASI to assess the severity of substance use problem and to plan treatments. The results from the current study suggest that after an initial contact with the addiction services, most service users with problematic alcohol use had elevated risk for recurrent hospitalization for alcohol-, polydrug- and psychiatric-related disorders. Older service users, moreover, have heterogeneous profiles and a significant proportion need earlier and integrated trauma, addiction and mental health services. People with dual diagnosis often benefit from
treatment plans with integrated focus on substance use disorder and comorbid mental health disorders [48].

The fragmentation of addiction services between the Swedish municipalities (social services), regions (health-care including primary care) and the state (compulsory care) and the absence of any agreement for coordination between service providers leave the burden on older people to coordinate their own treatment between different agencies. The absence of coordination between old-age care and addiction services might also be a barrier to detecting problematic alcohol use among older people. Given the high risk of recurrent hospitalization in the current study and the shortcomings of the Swedish addiction services, older service users with complex needs might benefit from an effort to complement the current mandatory ASI training for addiction service social workers with sensitization on the multi-dimensionality and consequence of problematic substance use among older people. Furthermore, training old-age care providers on late life substance use could provide social services with an additional point of contact for earlier identification of substance use problem and referral to treatment [49,50].

Older people prefer treatment plans which are accessible, non-confrontational and supportive [51]. They may benefit from age- and gender-tailored interventions which target different life domains [43,48,52–56]. Future studies should investigate what type of treatments older addiction service users are assigned to, the effectiveness of the provided treatments, if those treatments are age- and gender-specific and address the complex needs of older people with problematic substance use.

## Strengths and limitations of the study

This study used linked data from the Swedish addiction services, inpatient register and cause of death register throughout a 14-year period. The multiple-failure analysis technique used full hospitalization and mortality history of the study population sample in contrast to time to first event analysis, which does not consider subsequent hospitalizations or mortality after multiple hospitalizations. By including the mortality data in the multiple-failure data, we assumed mortality as equivalent to hospitalization. The statistical procedure is justified because death is the most serious health outcome and is not equivalent to non-informative censoring such as loss to follow-up or change of residence [37]. The sensitivity analysis results, moreover, did not change when the death event was removed from the multiple-failure data set.

The large entropy value indicating low classification error; high, most probably class membership, probabilities; and the random split-sample cross-validation procedures supported the classification quality of the selected five-class solution used in our study [24,57]. We acknowledge, however, that using latent classes as observed variables (as true classes) to predict a distal outcome can still introduce bias in effects estimation due to the true non-zero classification error inherent in modal class assignment.

This study is subject to the same limitations as all studies based on routinely collected health data. First, it is likely that the addiction services do not reach some older people living with alcohol use disorder due to several barriers. The study sample also included service users with problematic alcohol use who do not necessarily fulfill the criteria for alcohol use disorder diagnosis. Our study shows that almost two-thirds of addiction service users were hospitalized with alcohol-related diagnosis during the study period. Older people drinking alcohol at a risk level that does not exceed recommended drinking guidelines can still face the harmful consequences of alcohol [4,58].

Second, we cannot rule out the possibility of unmeasured confounders. For example, we did not have information on the actual treatment provided to service users after their social services assessment. The analysis did not include data from outpatient specialty addiction services or compulsory residential addiction care. These may be important confounders affecting the probability of hospitalization. Because recurrent hospitalization, a worse health outcome, was prevalent at follow-up, future studies should investigate the potential mediating effects of outpatient and residential addiction services between the index assessment and hospitalization or death.

Third, despite the registries having high quality and coverage and the multiple-failure analysis using complete hospitalization and mortality data for study participants, there were missing data for some covariates. Individuals, for example, might not respond to the questions used to calculate the ASI legal composite score leading to their exclusion from the analysis. Among all covariates, however, missing data were limited.

Finally, even if we adjusted for baseline socio-demographic characteristics, previous hospitalization, physical comorbidity index, several socio-demographic variables and clinical profiles can change across time which might, in turn, affect alcohol use pattern and latent class membership at different time-points. The purpose of the study, however, was to investigate differential risks for hospitalization among addiction service users following ASI assessment.

Previous studies on alcohol use disorder have examined if different subgroups of patients have varying disease prognosis and treatment outcomes in clinical and general population settings; however, these studies were based on a younger population and had not investigated the differential risk of alcohol-, polydrug- and psychiatric-related hospitalizations [59–61]. We demonstrated the possibility of using social service and longitudinal health-care data to follow the health outcome of older addiction service users in a context where the addiction care and treatment system is publicly funded and uncoordinated across municipal and regional systems. The results from the study might differ for a setting where the addiction treatment system is organized and reimbursed differently.

## CONCLUSION

Many older addiction service users within social services have repeated hospitalizations. The risk varies among distinct risk groups of older people with problematic alcohol use. Some older service users
with complex needs have an elevated risk for polydrug- and psychiatric-related recurrent hospital admission. Older female addiction service users, who often have late onset of problem drinking, have a greater risk of hospitalization due to dual diagnosis. Given the excessive rate of hospitalization due to substance use and psychiatric disorders and the differential risk throughout risk groups, older people may benefit from integrated mental, addiction and physical health care with age- and gender-sensitive components.

ACKNOWLEDGEMENTS
An award from The Swedish Research Council for Health, Working Life and Welfare (FORTE) to L.M.L. (grant no. 2016–07213) supported the study. Awards from the Royal Swedish Academy of Sciences and the Kempe Foundations to W.B.J. supported his doctoral study. The funders were not involved in the design, analysis and writing of the study or decision to submit manuscripts for publication. The Swedish National Graduate School for on Ageing and Health (SWEAH) supported the doctoral learning process. SWEAH is funded by the Swedish Research Council (grant no. 2013-08755) to develop creative cooperation among Swedish higher education institutions and cross-disciplinary collaboration among ageing and health researchers. The authors thank Dr Fredrik Snellman and Professor Malin Eriksson for reviewing and commenting on the manuscript.

DECLARATION OF INTERESTS
None.

AUTHOR CONTRIBUTIONS
Wossenseged Birhane Jemberie: Conceptualization; formal analysis; funding acquisition; methodology; visualization. Mojgan Padyab: Conceptualization; data curation; funding acquisition; project administration; supervision; validation. Dennis McCarty: Supervision; validation. Lena Lundgren: Funding acquisition; project administration; resources; supervision; validation.

ORCID
Wossenseged Birhane Jemberie https://orcid.org/0000-0002-4378-6803
Mojgan Padyab https://orcid.org/0000-0001-8296-5313
Dennis McCarty https://orcid.org/0000-0001-9014-2894
Lena M. Lundgren https://orcid.org/0000-0002-3529-2512

REFERENCES
1. Ahlner F, Sigström R, Rydberg Sterner T, Mellqvist Fässberg M, Kern S, Östling S, et al. Increased alcohol consumption among Swedish 70-year-olds 1976 to 2016: analysis of data from the Gothenburg H70 birth cohort studies, Sweden. Alcohol Clin Exp Res. 2018;42:2403–12.
2. Han BH, Moore AA, Ferris R, Palamar JJ. Binge drinking among older adults in the United States, 2015 to 2017. J Am Geriatr Soc. 2019;67:2139–44.
3. Soler-Vila H, Ortolá R, García-Esquinas E, León-Muñoz LM, Rodríguez-Artalejo F. Changes in alcohol consumption and associated variables among older adults in Spain: a population-based cohort study. Sci Rep. 2019;9:10401.
4. Kuerbis A. Substance use among older adults: an update on prevalence, etiology, assessment, and intervention. Gerontology. 2020;66:249–58.
5. Van Montfoort-De RKFG, De Weert-Van OGH, Beurmanjer H, Koekkoek B. Late-onset alcohol dependence: patient-reported problems. Addict Res Theory. 2017;25:139–45.
6. Shakaï I, Bergen G, Haddad YK, Kakara R, Moreland BL. Fall-related emergency department visits involving alcohol among older adults. J Safety Res. 2020;74:125–31.
7. Holton A, Boland F, Gallagher P, Fahey T, Kenny RA, Cousins G. Longitudinal prevalence of potentially serious alcohol-medication interactions in community-dwelling older adults: a prospective cohort study. Eur J Clin Pharmacol. 2019;75:569–75.
8. Caputo F, Vignoli T, Leggio L, Addolorato G, Zoli G, Bernardi M. Alcohol use disorders in the elderly: a brief overview from epidemiology to treatment options. Exp Gerontol. 2012;47:411–6.
9. Kendler KS, Ohlsson H, Sundquist J, Sundquist K. Alcohol use disorder and mortality across the lifespan: a longitudinal cohort and co-relative analysis. JAMA Psychiatry. 2016;73:575–81.
10. Strandberg AY, Trygg T, Pitkälä KH, Strandberg TE. Alcohol consumption in midlife and old age and risk of frailty: alcohol paradox in a 30-year follow-up study. Age Ageing. 2018;47:248–54.
11. Jiang H, Griffiths S, Callinan S, Livingston M, Vally H. Prevalence and sociodemographic factors of risky drinking in Australian older adults. Drug Alcohol Rev. 2020;39:684–93.
12. Graham K, Schmidt G. The effects of drinking on health of older adults. Am J Drug Alcohol Abuse. 1998;24:465–81.
13. Sacco P, Bucholz KK, Spitznagel EL. Alcohol use among older adults in the National Epidemiologic Survey on alcohol and related conditions: a latent class analysis. J Stud Alcohol Drugs. 2009;70:829–38.
14. Wu LT, Blazer DG. Substance use disorders and psychiatric comorbidity in mid and later life: a review. Int J Epidemiol. 2014;43:304–17.
15. Devanand DP. Comorbid psychiatric disorders in late life depression. Biol Psychiatry. 2002;52:236–42.
16. Mejldal A, Andersen K, Behrendt S, Bilberg R, Christensen AI, Lau CJ, et al. History of healthcare use and disease burden in older adults with different levels of alcohol use. A register-based cohort study. Alcohol Clin Exp Res. 2021;45:1237–48.
17. Sacco P, Unick GJ, Kuerbis A, Koru AG, Moore AA. Alcohol-related diagnoses in hospital admissions for all causes among middle-aged and older adults: trends and cohort differences from 1993 to 2010. J Aging Health. 2015;27:1358–46.
18. Kohli M, Charilaou P, Rousseau C-P, Menezes R, Sanon M. History of healthcare use and disease burden in older adults with different levels of alcohol use. A register-based cohort study. Alcohol Clin Exp Res. 2021;45:1237–48.
19. Weiss AJ, Heslin KC, Barrett ML, Izar R, Bierman AS. Opioid-Related Inpatient Stay and Emergency Department Visits Among Patients Aged 65 years and Older, 2010 and 2015: Statistical Brief no. 244. Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Rockville, MD: Agency for Healthcare Research and Quality; 2018.
20. Han BH, Tuazon E, Kunins HV, Paone D. Trends in inpatient discharges with drug or alcohol admission diagnoses to a skilled nursing facility among older adults, New York City 2008–2014. Harm Reduct J. 2020;17(1):99.
21. Swedish Council for Information on Alcohol and Other Drugs (CAN). Drug trends in Sweden. The Swedish Council for Information on Alcohol and Other Drugs: Report 180. Stockholm, Sweden: CAN; 2019.

22. The Council of Local Government Analysis. The Swedish Database for Municipal and Regional Benchmarking. Sweden: The Council of Local Government Analysis (RKA); 2021.

23. The Swedish Agency for Health and Care Services Analysis. Coordinated Health and Care Services. Stockholm, Sweden: Vårdsnäsanalys [The Swedish Agency for Health and Care Services Analysis]; 2016.

24. Jemberie WB, Padyab M, Snellman F, Lundgren L. A multidimensional latent class analysis of harmful alcohol use among older adults: subtypes within the Swedish Addiction Severity Index registry. J Addict Med. 2020;14:e89–99.

25. Makela K. Studies of the reliability and validity of the addiction severity index. Addiction. 2004;99:398–410. discussion 311–398.

26. Nystrom S, Andrén A, Zingmark D, Bergman H. The reliability of the Swedish version of the Addiction Severity Index (ASI). J Subst Use. 2010;15:330–9.

27. Ludvigsson JF, Andersson E, Ekholm F, Feychtung M, Kim J-L, Reutervall C, et al. External review and validation of the Swedish national inpatient register. BMC Public Health. 2011;11:450.

28. Brooke HL, Talbäck M, Hörnblad J, Johansson LA, Ludvigsson JF, Druid H, et al. The Swedish cause of death register. Eur J Epidemiol. 2017;32:765–73.

29. Bergman D, Hagström H, Capusan AJ, Mårdil K, Nyberg F, Sundquist K, et al. Incidence of ICD-based diagnoses of alcohol-related disorders and diseases from Swedish nationwide registers and suggestions for coding. Clin Epidemiol. 2020;12:1433–42.

30. The National Board of Health and Welfare. Anvisningar för kodningar av bruk och missbruk av alkohol [Instructions for coding use and abuse of alcohol]. Sweden: Socialstyrelsen [The National Board of Health and Welfare]; 2016.

31. Schmutte T, Dunn CL, Sledge WH. Predicting time to readmission in patients with recent histories of recurrent psychiatric hospitalization: a matched-control survival analysis. J Nerv Ment Dis. 2010;198:860–3.

32. Vest JR, Gamm LD, Oxford BA, Gonzalez MI, Slawson KM. Determinants of preventable readmissions in the United States: a systematic review. Implement Sci. 2010;5:88.

33. Mudge AM, Kasper K, Clair A, Redfern H, Bell JJ, Barras MA, et al. Recurrent readmissions in medical patients: a prospective study. J Hosp Med. 2011;6:61–7.

34. Donisi V, Tedeschi F, Wahlbeck K, Haaromo P, Amaddeo F, Preischarge factors predicting readmissions of psychotic patients: a systematic review of the literature. BMC Psychiatry. 2016;16:449.

35. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005;43:1130–9.

36. Andersen PK, Gill RD. Cox’s regression model for counting processes: a large sample study. Ann Stat. 1982;10(4):1100–120.

37. Westbury LD, Syddall HE, Simmonds SJ, Cooper C, Sayer AA. Identification of risk factors for hospital admission using multiple-failure survival models: a toolkit for researchers. BMC Med Res Methodol. 2016;16:46–6.

38. Lin DY, Wei LJ. The robust inference for the Cox proportional hazards model. J Am Stat Assoc. 1989;84:1074–8.

39. StataCorp. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC; 2017.

40. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. PLOS Med. 2007;4:e296.

41. Benchimol EI, Steen L, Guttmann A, Harron K, Moher D, Petersen I, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. PLOS Med. 2015;12:e1001885.

42. Johnson I. Alcohol problems in old age: a review of recent epidemiological research. J Geriatr Psychiatry. 2000;15:575–81.

43. Bartels SJ, Blow FC, Van Citters AD, Brockmann LM. Dual diagnosis among older adults: co-occurring substance abuse and psychiatric illness. J Dual Diagn. 2006;2:9–30.

44. Dombrowski D, Norrell N, Holroyd S. Substance use disorders in elderly admissions to an academic psychiatric inpatient service over a 10-year period. J Addict. 2016;2016:4973018.

45. Shenvi CL, Weaver MA, Biese KJ, Wang Y, Revankar R, Fatade Y, et al. Identification and characterization of older emergency department patients with high-risk alcohol use. J Am Coll Emerg Phys. 2020;1:804–11.

46. Flint A, Merali Z, Vaccarino FE. Substance Use in Canada: Improving Quality of Life: Substance Use and Aging. Ottawa, ON, Canada: Canadian Centre on Substance Use and Addiction; 2018.

47. Royal College of Psychiatrists (RCP). Our Invisible Addicts (College Report CR211). London, UK: RCP; 2018.

48. Baker AL, Thornton KL, Hiles S, Hides L, Lubman DI. Psychological interventions for alcohol misuse among people with co-occurring depression or anxiety disorders: a systematic review. J Affect Disord. 2012;139:217–29.

49. Castle N, Smith ML, Wolf DG. Long-term care and alcohol use. In: Kuerbis A, Moore AA, Sacco P, Zanjani F, editors Alcohol and Aging: Clinical and Public Health Perspectives. Cham, Switzerland: Springer International Publishing; 2016. p. 233–46.

50. White JB, Duncan DF, Burr BD, Nicholson T, Bonaguro J, Abrahamson K. Substance abuse policies in long-term care facilities: a survey with implications for education of long-term care providers. Educ Gerontol. 2015;41:519–26.

51. Holland JM, Rozalski V, Beckman L, Rakhkovskaya LM, Klingspor KL, Donohue B, et al. Treatment preferences of older adults with substance use problems. Clin Gerontol. 2016;39:15–24.

52. Epstein EE, Fischer-Elber K, Al-Otaiba Z. Women, aging, and alcohol use disorders. J Women Aging. 2007;19:31–48.

53. Klingemann H, Gomez V. Masculinity issues in addiction treatment in Swiss inpatient alcohol programs: bringing men’s treatment needs back to the research agenda. J Men’s Health. 2010;7:211–20.

54. Kuerbis A, Sacco P. A review of existing treatments for substance abuse among the elderly and recommendations for future directions. Subst Abuse Res Treat. 2013;7:13–37.

55. MacFarland NS. Outpatient Treatment Approaches. Services and Outcomes for Older Addicted Adults. Ann Arbor: State University of New York at Albany; 2014. p. 127.

56. Rao R, Crome I, Crome P, Iliffe S. Substance misuse in later life: challenges for primary care: a review of policy and evidence. Prim Health Care Res Dev. 2019;20:e117–7.

57. Clark SL & Muthén BO Relating Latent Class Analysis Results to Variables not Included in the Analysis. Unpublished Manuscript. University of California, Los Angeles; 2009. https://www.statmodel.com/download/relatinglca.pdf

58. Wadd S, Papadopoulos C. Drinking behaviour and alcohol-related harm amongst older adults: analysis of existing UK datasets. BMC Res Notes. 2014;7:741.

59. Litt MD, Babor TF, Delbonca FK, Kadden RM, Cooney NL. Types of alcoholics 2. Application of an empirically derived typology to treatment matching. Arch Gen Psychiatry. 1992;49:609–14.

60. Moss HB, Chen CM, Yi H-Y. Prospective follow-up of empirically derived alcohol dependence subtypes in wave 2 of the National Epidemiologic Survey on alcohol and related conditions (NESARC): recovery status, alcohol use disorders and diagnostic criteria, alcohol consumption behavior, health status, and treatment seeking. Alcohol Clin Exp Res. 2010;34:1073–83.
61. Hesselbrock MN, Hesselbrock VM, Chan G, Del Boca F, Chartier K. Subtypes of alcohol dependence and 36-year mortality. Alcohol Clin Exp Res. 2020;44:1658–65.

SUPPORTING INFORMATION
Additional supporting information may be found in the online version of the article at the publisher’s website.