RESEARCH REPORT

ADDICTION   SSA

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

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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).

Conclusions: Older addiction service users in Sweden have varying risks of hospitalization due to alcohol use, polydrug use and psychiatric disorders. Older people with problematic alcohol use who have multiple needs and are assessed in social services may benefit from earlier interventions with an integrated focus on substance use and mental health.

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 speciality 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

	N = 1741
Subtypes, n (%)	(n = 1741)
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 (%)	(n = 1741)
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) (n = 1741)
Past year hospitalization: ARDDS, median (IQR)	0 (0, 2) (n = 1741)
Past year hospitalization: polydrug, median (IQR)	0 (0, 0) (n = 1741)
Past year hospitalization: psychiatric No ARDDS, median (IQR)	0 (0, 0) (n = 1741)
Past year hospitalization: dual psychiatric and ARDDS, median (IQR)	0 (0, 0) (n = 1741)
Age group, n (%), years	(n = 1741)
50–64	1538 (88.3%)
65 or older	203 (11.7%)
Sex, n (%)	(n = 1741)
Male	1250 (71.8%)
Female	491 (28.2%)
Marital status, n (%)	(n = 1740)
Married	308 (17.7%)
Civil partnership	202 (11.6%)
Separated/widowed	1106 (63.5%)
Single, never married/cohabited	124 (7.1%)
Migration status, n (%)	(n = 1727)
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 (%)	(n = 1722)
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 (%)	(n = 1721)
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 (%)	(n = 1739)
More than 100 000 people	805 (46.2%)
Between 10 000 and 100 000	778 (44.7%)
Fewer than 10 000	156 (9.0%)

T A B L E   1   (Continued)

	N = 1741
Accommodation status, n (%)	(n = 1738)
Own or housing with own contract	1280 (73.5%)
Housing with second-hand contract	74 (4.3%)
Living in parents' home	100 (5.7%)
Ordinary housing provided by social services	14 (0.8%)
Housing with special services in accordance with Social Service Act	71 (4.1%)
Hotel	10 (0.6%)
Homeless	139 (8.0%)
Other	50 (2.9%)
ASI legal composite score, median (IQR)	0 (0, 0) (n = 1637)

IQR, interquartile range; ARDDS, alcohol -related disorders and diseases; ASI, Addiction Severity Index.
Percentage values do not add to 100% because missing observations were also considered.

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), Voung–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

TABLE 2 Class indicator probabilities for the five subtypes of problematic alcohol use

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

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'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
- Highest education level
- 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

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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.

186 days post-ASI assessment. Class membership to EO:MD was associated with reduced risk of alcohol-related outcome (aHR = 0.68; 95% CI = 0.51, 0.89) while EO:PP had an increased risk of such events (aHR = 1.34; 95% CI = 1.02, 1.75) (Table 5). Previous ARDDS-related hospitalization in the year pre-initial ASI, not being married and being separated/widowed; higher education level; and having physical comorbidities were associated with an increased risk of ARDDS outcomes. Women were less likely to experience ARDDS-related outcome (see Table 5).

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).
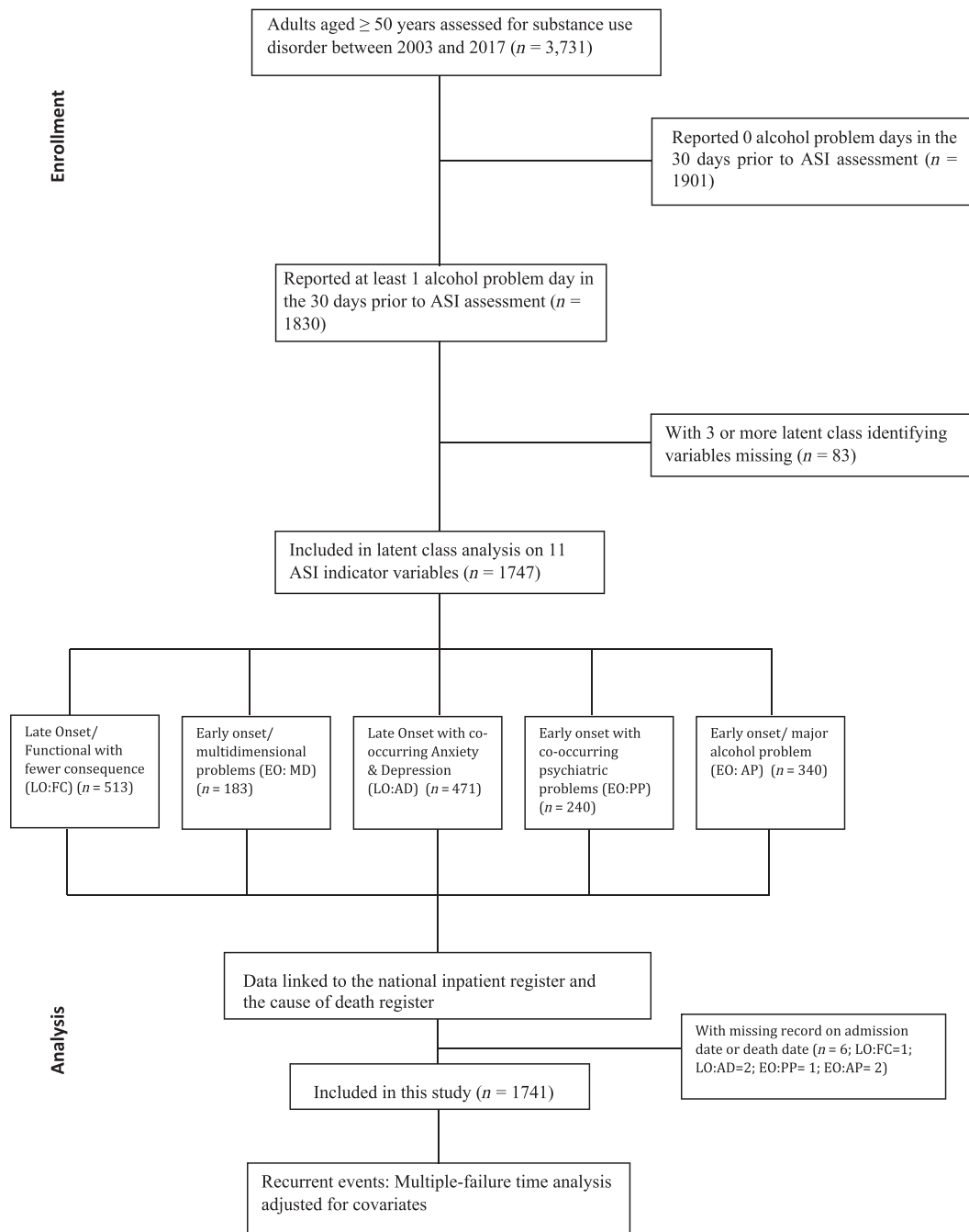
FIGURE 1 Analysis cohort

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
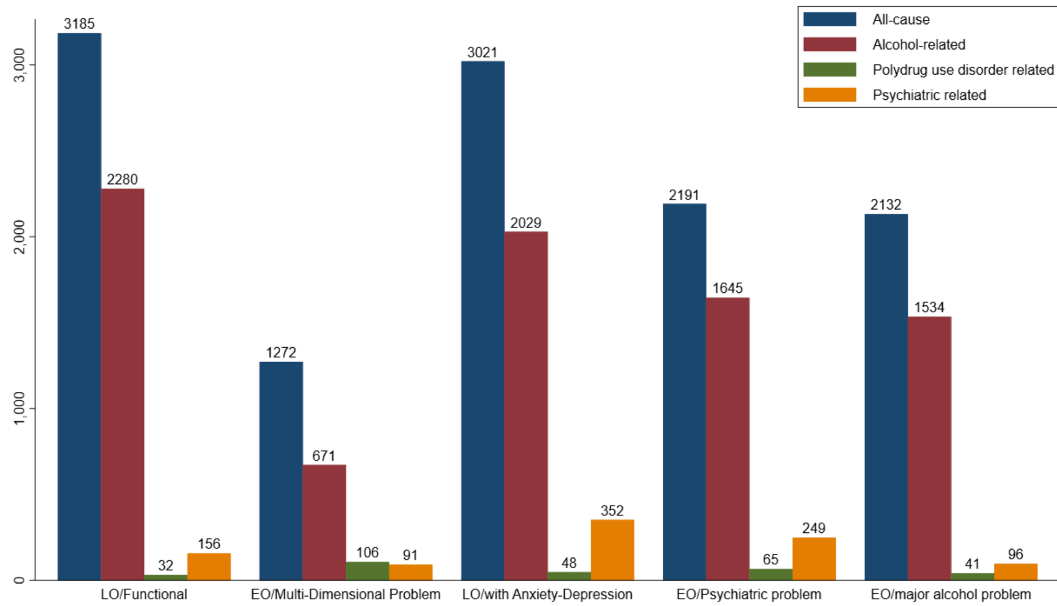
FIGURE 2 Total number of failures (hospitalization and mortality) among five classes of harmful alcohol use. LO/functional, late onset/ functional with fewer consequences; EO/multi-dimensional problem, early onset/multi-dimensional problems; LO/with anxiety-depression, late onset with co-occurring anxiety and depression; EO/psychiatric problem, early onset with co-occurring psychiatric problems; EO/major alcohol problem, p;early onset/major alcohol problem

FIGURE 3 Percentage of individuals with at least one event stratified according to the five classes. LO/functional, late onset/functional with fewer consequences; EO/multi-dimensional problem, early onset/multi-dimensional problems; LO/with anxiety-depression, late onset with co-occurring anxiety and depression; EO/psychiatric problem, early onset with co-occurring psychiatric problems;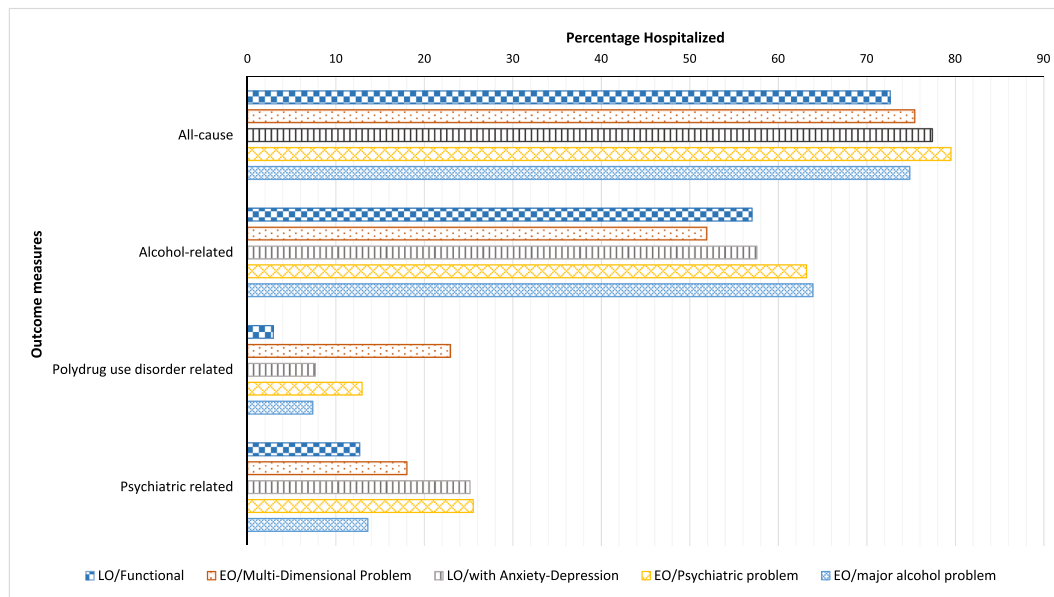 EO/major alcohol problem, early onset/major alcohol problem. *Note:* The percentages do not add to 100 because of overlap within the outcome categories

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

	All-cause	ARDDS	Polydrug	Psych
Subtypes	HR (95% CI)			
Late onset/functional with fewer consequences	Ref	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.

compared to the LO:FC subtype. EO:PP has a history of delirium tremens, repeated out- and inpatient treatment episodes for managing alcohol problem and elevated prevalence of familial presence of problematic alcohol use [24].

Another subtype, EO:MD, had a lower risk for ARDDS-related hospitalization. The analysis also suggested that the EO:PP and EO:MD subtypes had greater risk for ARDDS hospitalization existing with comorbid drug use disorder (polydrug use disorder). Approximately 30% of EO:PP and 66% of EO:MD class members reported recent drug use when the baseline ASI was completed and the EO:MD class reported a history of at least four drug overdose episodes [24].

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 fulfil 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.

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.

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SUPPORTING INFORMATION

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