Research Report

Re-Hospitalisation of Alcohol Use Disorder Patients with and without Qualified Withdrawal and Rehabilitation Treatment

A Data-Linkage Study in Hamburg, Germany

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Abstract. *Aims*: This study (a) evaluates re-hospitalisation among alcohol use disorder (AUD) patients receiving different treatments and (b) simulates avoided re-hospitalisation if more patients received rehabilitation treatment. *Methods:* Electronic health records (2016–21) from patients living in Hamburg were obtained from two statutory health insurances (AOK Rheinland/Hamburg, DAK – Gesundheit) and pension funds (Deutsche Rentenversicherung Nord, Deutsche Rentenversicherung Bund). Analysed were patients receiving either (1) inpatient alcohol treatment (IAT, *n* = 306), (2) qualified withdrawal treatment (QWT) only (*n* = 487), or (3) QWT with rehabilitation (*n* = 101) after first outpatient F10.2-F10.4 diagnosis. Using weighted regression modelling, we compared re-hospitalisation during 12-months follow-up. *Results*: Patients entering QWT with rehabilitation had higher odds of *not* being re-hospitalised from any (OR: 1.84, 95 % CI [1.15, 2.95]) or alcohol-specific causes (OR: 1.87, 95 % CI [1.13, 3.10]) within 12-months follow-up compared to those with QWT only. There was no statistically significant difference in receiving IAT versus QWT only. If every second patient were to receive rehabilitation treatment, the number of patients without any all-cause re-hospitalisation during follow-up could have been increased from 45.8 % (95 % CI [42.6, 48.9]) to 50.7 % (95 % CI [47.5, 53.9]). *Conclusions:* Rehabilitation treatment seems critical to achieving measurable health improvements in AUD patients.

Keywords: alcohol dependence, inpatient treatment, qualified withdrawal treatment, rehabilitation treatment, data linkage

Rehospitalisierung von Patientinnen und Patienten mit Alkoholkonsumstörung mit und ohne qualifizierter Entzugs- und Rehabilitationsbehandlung: eine Data-Linkage-Studie in Hamburg

Zusammenfassung. *Zielsetzung:* Diese Studie untersucht (a) das Risiko einer Rehospitalisierung von Patient_innen mit Alkoholkonsumstörung in Abhängigkeit unterschiedlicher Behandlungswege und (b) simuliert die vermeidbare Rehospitalisierung für Szenarien, in denen mehr Patient_innen eine Rehabilitationsbehandlung erhalten würden. *Methodik:* Datengrundlage sind Leistungsdaten (2016–21) zweier gesetzlicher Krankenkassen (AOK Rheinland/Hamburg, DAK – Gesundheit) sowie Rentenversicherungen (Deutsche Rentenversicherung Nord, Deutsche Rentenversicherung Bund) von Patient_innen der Region Hamburg. Die analytische Stichprobe umfasst Patient_innen mit (1) nicht näher spezifizierter stationärer Alkoholbehandlung (SAB, *n* = 306), (2) ausschließlich qualifizierter Entzugsbehandlung (QE, *n* = 487) oder (3) QE mit anschließender Rehabilitationsbehandlung (*n* = 101) nach erster ambulanter F10.2-F10.4 Diagnose. Rehospitalisierungen aus jeglichem Anlass bzw. mit alkoholspezifischer Diagnose im 12-Monats-Follow-Up wurden regressionsanalytisch zwischen den Behandlungsgruppen verglichen. *Ergebnisse:* Im Vergleich zu Patient_innen mit ausschließlicher QE, hatten Patient_innen mit anschließender Rehabilitationsbehandlung eine höhere Wahrscheinlichkeit im 12-Monats-Follow-Up *nicht* erneut hospitalisiert zu werden (*all-cause*, OR: 1.84, 95 % CI [1.15, 2.95]; alkoholspezifisch, OR: 1.87, 95 % CI [1.13, 3.10]). Es gab keinen statistisch signifikanten Unterschied zwischen SAB und ausschließlicher QE. Hätte jede_r zweite Patient_in eine Rehabilitationsbehandlung erhalten, hätte sich der Anteil der Patient_innen ohne Rehospitalisierung im 12-Monats-Follow-Up von 45.8 % (95 % CI [42.6, 48.9]) auf 50.7 % (95 % CI [47.5, 53.9]) erhöht. *Schlussfolgerungen*: Eine Rehabilitationsbehandlung scheint entscheidend zu sein, um messbare gesundheitliche Verbesserungen bei Patient_innen mit Alkoholkonsumstörung zu erzielen.

Schlüsselwörter: Alkoholabhängigkeit, stationäre Behandlung, qualifizierte Entzugsbehandlung, Rehabilitationsbehandlung, Datenverknüpfung

Introduction

In Germany, about 1.4 million adults are estimated to meet DSM-IV alcohol dependence criteria (Atzendorf et al., 2019). Alcohol use disorder (AUD) is a mental illness characterised by behavioural, cognitive, and physiological symptoms resulting from the repeated and heavy use of alcohol (ICD-10 F10.2 [World Health Organization, 1993]). Chronic heavy use of alcohol amplifies the risk of many diseases, including but not limited to liver diseases, cancers, cardiovascular diseases, and neuropsychiatric disorders (Rehm et al., 2017). In addition to deaths from conditions partially linked to alcohol use, such as injuries or cancer, about 21,700 individuals have died from causes entirely attributable to alcohol use (i.e., alcohol-specific deaths) in Germany in 2021 (Kraus et al., 2024). A large proportion of those deaths have occurred in people with a diagnosed or probable AUD (Kraus et al., 2023).

The high disease burden attributable to alcohol use highlights the need for specialised treatment for people with AUD. According to the German treatment guidelines (Kiefer et al., 2021), post-acute treatment is recommended after completing a qualified withdrawal treatment (QWT), which constitutes a 3-week inpatient treatment comprising physical withdrawal and motivational interventions for abstinence building. However, data from the city-state Bremen suggest that only 5% of AUD patients started a post-acute treatment (e.g., rehabilitation treatment) in the first 10-months after an inpatient alcohol stay (including but not limited to QWT [Mockl et al., 2024]).

While current treatment guidelines imply that QWT and post-acute treatment reflects best treatment practices, no study has yet evaluated this recommendation with respect to achieving physical and mental health improvements. We seek to fill this research gap and hypothesise that individuals with a first AUD diagnosis have lower rates of inpatient healthcare utilisation if they received QWT and rehabilitation treatment compared to those without rehabilitation treatment. Based on the empirically determined effect sizes of QWT and rehabilitation treatment, we performed a simulation to estimate how many re-hospitalisations could be avoided within 12-months follow-up, if more AUD patients with an initial acute treatment were to receive post-acute rehabilitation treatment.

Methodology

The hypothesis and study plan for this investigation have been published in a study protocol (Manthey et al., 2024). Departures from the study plan are documented in Electronic Supplementary Material (ESM) 1.

Data Sources and Linkage

We linked electronic health records from two large statutory health insurances (SHI; Allgemeine Ortskrankenkasse [AOK] Rheinland/Hamburg, Deutsche Angestelltenkrankenkasse [DAK – Gesundheit]) and two German pension funds (Deutsche Rentenversicherung Nord; Deutsche Rentenversicherung Bund) for the years 2016 to 2021. The data from SHI providers include insured persons' information and addiction-related and other medical outpatient and inpatient treatment, outpatient surgeries (hospital stays without overnight stays), and outpatient prescriptions. The data from pension funds cover outpatient or inpatient rehabilitation in addiction medicine.

Since there is no common identifier in the four different datasets, a project-specific tool was developed to create cryptographically encrypted identifiers based on personally identifiable variables (first name, last name, birth year, gender) to link the relevant data into a single analytical dataset (for further details, see Manthey et al., 2024).

Definitions of Interventions

We considered three types of intervention, namely two different types of inpatient stay and one rehabilitation service that was delivered in an inpatient or outpatient setting. We used SHI data, including information on diagnoses and procedure classification (Operationen- und Prozedurenschlüssel [OPS]), to classify inpatient stays. Two types of OPS codes were considered, referring to treatment for mental and psychosomatic disorders and behavioural disorders in adults (9–6x), as well as motivational treatment for substance dependency (8–985). By combining OPS codes with ICD-10 F10.x diagnoses, the treatment was determined to focus primarily on AUD. Based on a combination of OPS codes and ICD-10 diagnoses, the following two treatment types were identified, consistent with a previous publication (Manthey et al., 2025):

- Inpatient alcohol treatment (IAT): defined as any inpatient stay with a main diagnosis of F10.2, F10.3, or F10.4, in addition to OPS codes 9–60x, 9–61x, 9–62x, or 9–63x but not 8–985 or 9–647.
- QWT: defined as any inpatient stay with a main diagnosis of F10.2, F10.3, or F10.4 or any main diagnosis of F10.x but a secondary diagnosis of F10.2, in addition to OPS codes 8–985 or 9–647.

Of the resulting two exclusive treatment types, QWT was assumed to be the more intensive treatment including psychosocial elements to foster abstinence motivation. Specific information on the interventions provided, including

pharmacotherapy, is not available for both treatment types. Treatment duration was determined using the first and last day in hospital.

Alcohol rehabilitation included all rehabilitation treatment episodes from the pension funds with F10.x approval diagnosis, approval grouping referred to AUD, or the underlying condition was coded as AUD. From SHI data, we included additional rehabilitation treatment episodes with F10.x main diagnosis or F10.x diagnosis of application. In few cases, treatment episodes were present in both data sources, but duplicates (same start and end dates and same diagnoses) were removed. Rehabilitation treatment in Germany can be inpatient or outpatient and involves a range of psychological, occupational, and medical interventions aimed at reintegrating the patient into society and the workforce. Rehabilitation programmes are mostly abstinence-focused (Enke et al., 2022).

Study Population

The study population was selected based on all SHI-insured patients living in the city-state of Hamburg that met the following criteria (see Figure 1): 1) diagnosis of alcohol dependence or withdrawal state (ICD-10: F10.2, F10.3, or F10.4) in an outpatient setting, 2) confirmed diagnosis (as opposed to a suspected diagnosis), 3) diagnosis received in at least two different cases (e.g., by the same outpatient practitioner but in two different quarters or in two hospital episodes; M2BF definition according to Epping et al., 2024), 4) complete insurance coverage for at least 12 months before and after the first diagnosis in the observation period, and 5) diagnosis received in 2017 or later. Among those meeting these criteria (n=7,248), we identified patients in three exclusive treatment groups:

a. IAT (n=306): all patients with at least one inpatient stay within 365 days of their first diagnosis and no QWT or rehabilitation treatment in the observation period.
b. QWT (n=487): all patients that completed a QWT and have not started a subsequent rehabilitation treatment within 365 days of their first diagnosis in the observation period.
c. Rehabilitation treatment (n=101): all patients that completed a QWT and started a rehabilitation treatment within 365 days of their first diagnosis in the observation period.

Patients remaining unclassified (n=4,422) had neither an IAT nor a QWT and/or rehabilitation treatment but may have had other alcohol treatment (e.g., outpatient brief psychiatric or psychological consultation, prescription of alcohol-specific medications) in the observation period

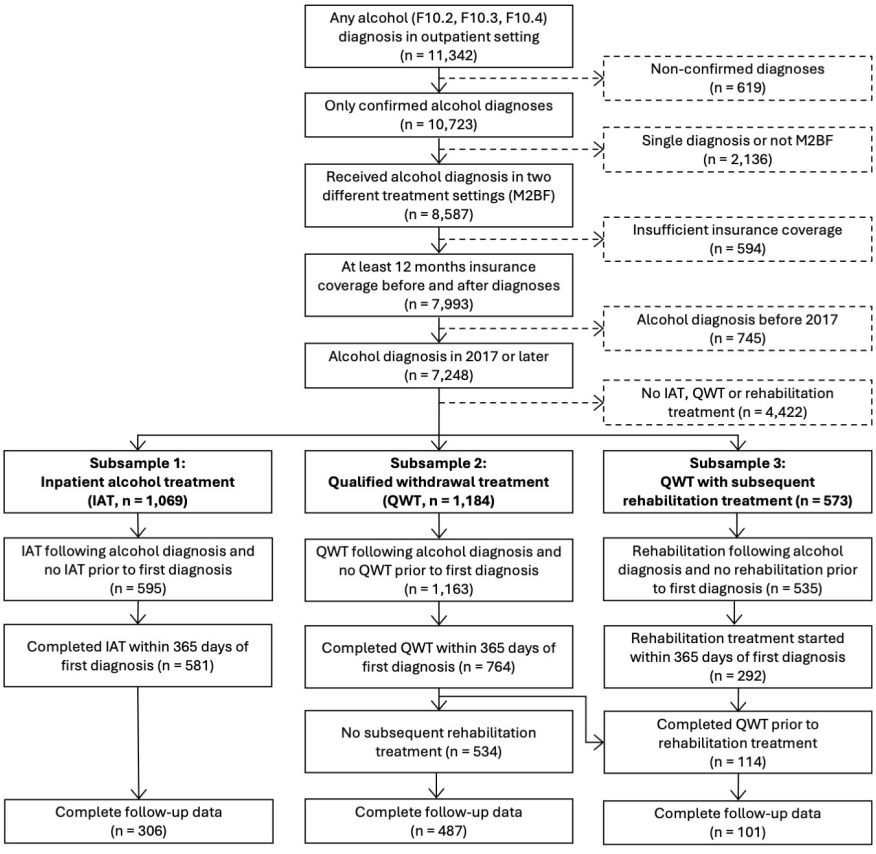

Figure 1. Flowchart for selecting the study population.

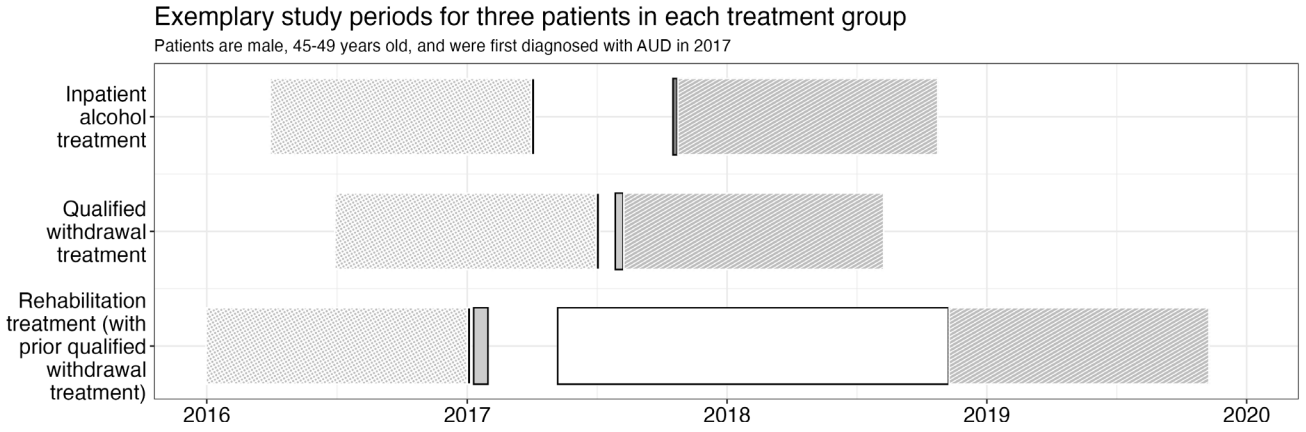

Figure 2. Exemplary study periods for three patients in each treatment group. Black line: alcohol use disorder diagnosis; dotted area: individual 12-months look-behind period; dark grey box: inpatient alcohol treatment; light grey box: qualified withdrawal treatment; white box: rehabilitation treatment; shaded area: individual 12-months follow-up periods.

that were not considered in this analysis. These patients were therefore excluded from the study population. Details on alcohol treatment of the underlying SHI-insured patient population are available elsewhere (Manthey et al., 2025).

Follow-up and Outcome Measures

Although most patients had multiple inpatients and/or outpatient stays in the observation period, we limited our analysis to the first IAT, QWT, and/or rehabilitation treatment. Individual follow-up periods of 12-months length were defined starting one day after the last (IAT, QWT, and/or rehabilitation) treatment day. Figure 2 exemplifies these follow-up periods (shaded blocks) for three patients in the three treatment groups.

The primary outcome was the total number of days in hospital with any diagnosis, including but not limited to alcohol-specific diagnoses during 12-months follow-up. The secondary outcome was the total number of days in hospital with a primary diagnosis fully attributable to alcohol use (ICD-10: E24.4, F10.0-F10.9, G31.2, G62.1, G72.1, I42.6, K29.2, K70.0–K70.4, K70.9, K85.2, K86.0, R78.0, X45, X65, Y15, Y90, Y91 [World Health Organization, 1993]). Risk of (alcohol-specific) re-hospitalisation is a commonly used outcome in the literature (e.g., Bach et al., 2025; Friesen et al., 2024; Koopmann et al., 2024, however, we acknowledge limitations inherent to this indicator. While every alcohol-specific re-hospitalisation likely constitutes a relapse, not every relapse results in a re-hospitalisation.

Covariates

The following covariates were available for all patients from the SHI data: sex (binary: male, female), age at AUD diagnosis (continuous), employment status, date of first AUD diagnosis (year, quarter), number of days between first AUD diagnosis and first treatment (according to treatment group; continuous), and number of inpatient stays within 12-months of first AUD diagnosis (binary: no/one inpatient stay vs. two or more inpatient stays). Predominant employment status in the 12-months look-behind period was grouped into three categories: employed (including self-employed), unemployed, and other (e.g., retired, student, asylum status).

We computed the Elixhauser comorbidity index for the 12-months look-behind period using the *comorbidity* R package version 1.0.7 (Gasparini, 2018). We included all primary and secondary diagnoses in inpatient settings, confirmed diagnoses in outpatient settings, primary diagnoses in rehabilitation settings, as well as any ICD-10 codes recorded for work disability and other health insurance benefits. The Elixhauser comorbidity index reflects the number of comorbidities along 31 disease categories. We used hierarchical coding for same disease categories of different severity. As our sample consists of AUD patients, we excluded alcohol as a disease category, resulting in a sum score of 0 (no diagnosis in any disease category) to 30 (diagnoses in all disease categories). We dichotomised the Elixhauser comorbidity index (henceforth: comorbidity; Median: 2, IQR: 1–4) into having 0 or 1 vs. having 2 or more comorbidities.

Statistical Analysis

We used a matching weight method to achieve comparability between the treatment samples in the 12-months look-behind period (Shurrab et al., 2023), accounting for the following covariates: sex, age at and date of AUD diagnosis, employment status, and comorbidity (for details, see ESM 2).

Visual exploration of the outcome distributions (i.e., number of days in hospital during 12-months follow-up) revealed that they were heavily right-skewed with a very large number of zero observations (i.e., zero days in hospital during follow-up, ESM 3). We therefore fitted weighted zero-inflated negative binomial regression models using the R package *pscl* version 1.5.9 (Zeileis et al., 2008) accounting for multiple testing using Bonferroni adjustment (Abdi, 2007). The first component of these models estimates the likelihood of being an excess zero in a binary model (i.e., zero days in hospital during follow-up), while the second component estimates the count outcome (i.e., number of days in hospital during follow-up). This approach allows a separate estimation of both probability and length of hospitalisation. Treatment group (i.e., IAT, QWT [reference category], rehabilitation) was the independent variable in both model components, which were further adjusted for the number of days between first AUD diagnosis and first treatment and having two or more inpatient stays 12-months following the first AUD diagnosis. Matching weights were applied in all models. Model coefficients were exponentiated to reflect Odds Ratios (OR) for the zero-inflated component and Incidence Rate Ratios (IRR) for the count component. We estimated robust standard errors using bootstrapping with 1.500 replications (R package *boot* version 1.3–30 [Canty & Ripley, 2024]). In a sensitivity analysis, we repeated the main analysis excluding patients with irregular discharge from IAT and QWT (see ESM 4).

Finally, we performed a simulation based on the results from the regression analysis, in which we increased the number of patients with a first AUD diagnosis that would receive rehabilitation treatment following their initial IAT and/or QWT. We compared the observed reality, in which 101 out of 894 patients (11.3 %) entered rehabilitation treatment, to three alternative scenarios. For the alternative scenarios, we assumed that 20 %, 35 %, and 50 % of AUD patients had entered rehabilitation treatment. In a first step, we sampled patients from the IAT and QWT groups who would receive subsequent rehabilitation treatment in the different simulation scenarios with 1,000 repetitions, accounting for each individual's probability to be in the rehabilitation group based on their matching weight. In a second step, we predicted all-cause and alcohol-specific hospitalisation during 12-months follow-up for each scenario using the above-described regression models. Thus, we relied on the regression-based effect sizes that consider the balancing weights (removing possible confounding due to sex, age at and date of AUD diagnosis, employment status, and comorbidity). The prediction yielded individual-level probabilities for each possible number of days in hospital (integers ranging from 0 to maximum observed value). These probabilities were compared to a randomly drawn probability from a uniform distribution ranging between 0 and 1. The non-event (zero hospital days) was assumed if the probability from the uniform distribution fell below the predicted probability. For example, if the predicted probability of zero hospital days was 60 % and a randomly drawn probability was 50 %, zero hospital days was assumed. If the same predicted probability was compared against a drawn probability of 80 %, at least one hospital day was assumed. By repeating these comparisons 1,000 times, we were able to account for the uncertainty of the prediction model, i.e., the effect size. We report the mean of the resulting distribution as point estimate and the 2.5 % and 97.5 % percentile as 95 % confidence interval.

Results

Sample Description

Across treatment groups, patients were about mid-age, predominantly male, and mostly employed or unemployed (see Table 1 for unweighted data). More than half of the patients received their first AUD diagnosis in 2017. Patients in all treatment groups had a median of two other diagnosed health conditions 12-months prior to their first AUD diagnosis. The median number of days between first AUD diagnosis and first treatment was 68 days, 80 days, and 68 days in the IAT, QWT, and rehabilitation treatment group, respectively. The median duration of the treatment was longest for the rehabilitation group (21 days of QWT plus 105 days of rehabilitation treatment), followed by QWT (15 days) and IAT (8 days). After weighting, the three treatment groups were comparable with regard to sex, age at and date of AUD diagnosis, employment status, and comorbidity (see the weighted sample description in Table ESM 1).

Re-Hospitalisation from All-Causes

Figure 3 depicts the weighted distribution of all-cause hospital days for patients of the three treatment groups. Patients receiving IAT had a median of one (IQR: 0–2) all-

Table 1. Sample description (unweighted)

	Inpatient alcohol treatment (*n* = 306)	Qualified withdrawal treatment only (*n* = 487)	Qualified withdrawal with subsequent rehabilitation treatment (*n* = 101)
Mean age at AUD diagnosis (SD)	49 (12.64)	48.26 (12.11)	45.63 (10.78)
Proportion of men, n (%)	227 (74.2)	347 (71.3)	69 (68.3)
Employment status, n (%)			
Employed	106 (34.6)	191 (39.2)	47 (46.5)
Unemployed	113 (36.9)	169 (34.7)	31 (30.7)
Other (e.g., retired, student)	87 (28.4)	127 (26.1)	23 (22.8)
Year of alcohol diagnosis, n (%)			
2017	154 (50.3)	286 (58.7)	59 (58.4)
2018	45 (14.7)	93 (19.1)	23 (22.8)
2019	67 (21.9)	56 (11.5)	13 (12.9)
2020	40 (13.1)	52 (10.7)	6 (5.9)
Elixhauser comorbidity index 12-months look-behind period, median (IQR)	2 (1–4)	2 (1–4)	2 (1–3)
Number of days between AUD diagnosis and treatment, median (IQR)	68 (36–185)	80 (32.5–186)	68 (37–136)
Number of days in treatment, median (IQR)	8 (6–15)	15 (10–21)	QWT: 21 (12–21) Reha: 105 (86–112)
Two or more IATs within 12 months after first AUD diagnosis, n (%)	53 (17.3)	19 (3.9)	2 (2.0)

Notes. Unweighted data. AUD: alcohol use disorder. CI: confidence interval. IAT: inpatient alcohol treatment. IQR: inter quartile range. SD: standard deviation. QWT: qualified withdrawal treatment. Reha: rehabilitation treatment.

cause hospital stays during 12-months follow-up with a median duration of three days (IQR: 0–19). This is similar to those with QWT only (one hospital stay, IQR: 0–2, with median duration of four days, IQR: 0–24), but higher compared to patients with QWT and subsequent rehabilitation treatment (zero hospital stays, IQR: 0–1, with median duration of zero days, IQR: 0–6).

Adjusted regression modelling (Table 2) yielded no statistically significant difference between the IAT and QWT groups (all *p*'s>.50). However, receiving subsequent rehabilitation treatment was associated with statistically significant higher odds of *not* having been hospitalised during follow-up compared to QWT only (i.e., zero hospital days; $p=.022$). For ease of interpretation, the inverse of the OR can be used to describe the effect of rehabilitation treatment on hospitalisation: since the OR=1.84 refers to the odds of *not* being hospitalised, the inverse OR ($1/1.84 \approx 0.54$) suggests that the odds of being hospitalised are 46% lower when entering rehabilitation treatment after QWT. For each additional day between first diagnosis and treatment, the odds of any hospitalisation subsequent to the treatment increases by 0.3% (1.003=1/0.997). When hospitalised, there was no difference in the number of inpatient days ($p>.050$). These findings were robust against excluding patients with irregular discharge (see ESM 4).

Re-Hospitalisation from Alcohol-Specific Causes

For alcohol-specific hospitalisations during 12-months follow-up, there was a median number of zero hospital stays with a median duration of zero days in all three treatment groups (IQRs for hospital stays, IAT: 0–1, QWT: 0–1, rehabilitation: 0–0; IQRs for days in hospital, IAT: 0–8, QWT: 0–10, rehabilitation: 0–0). The weighted distribution of alcohol-specific hospital days for the three treatment groups is shown in Figure 3.

There was no statistically significant difference in the odds or the number of days with alcohol-specific hospitalisation between the IAT and QWT group (all *p*'s>.50, Table 2). The odds of having zero hospital days during follow-

Table 2. Results from zero-inflated negative binomial regression models for re-hospitalisation during 12-months follow-up

	Zero-inflated component		Count component	
	OR (95 % CI)	Robust 95 % CI	IRR (95 % CI)	Robust 95 % CI
Outcome 1: All-cause hospitalisation				
Treatment (reference: qualified withdrawal)				
Inpatient alcohol	1.08 (0.77–1.51)	0.75–1.53	0.97 (0.77–1.22)	0.73–1.26
Rehabilitation	1.84 (1.15–2.95) *	1.12–3.05	0.99 (0.67–1.47)	0.55–1.53
Time between alcohol diagnosis and treatment	0.997 (0.995–0.998) ***	0.995–0.998	1.000 (0.999–1.001)	0.998–1.001
Two or more inpatient stays (reference: none/one)	0.34 (0.17–0.71) **	0.13–0.65	1.13 (0.80–1.59)	0.80–1.55
Outcome 2: Alcohol-specific hospitalisation				
Treatment (reference: qualified withdrawal)				
Inpatient alcohol	1.34 (0.97–1.86)	0.97–1.90	1.03 (0.80–1.32)	0.73–1.39
Rehabilitation	1.87 (1.13–3.10) *	1.12–3.252	1.42 (0.92–2.20)	0.77–2.23
Time between alcohol diagnosis and treatment	0.997 (0.996–0.999) **	0.996–0.999	0.999 (0.998–1.000)	0.998–1.000
Two or more inpatient stays (reference: none/one)	0.31 (0.18–0.55) ***	0.17–0.54	1.14 (0.81–1.59)	0.73–1.68

Notes. *** $p < .001$, ** $p < .01$, * $p < .05$. Zero-inflated negative binomial regression models account for matching weights. Zero-inflated component: Odds Ratio (OR) of having *not* been hospitalised during follow up. Count component: Incidence Rate Ratio (IRR) of hospital days. Robust standard errors were estimated using bootstrapping with 1,500 replications. All-cause hospitalisation: Theta = 0.71, alcohol-specific hospitalisation: Theta = 0.99. P-values adjusted using Bonferroni correction for two dependent outcomes.

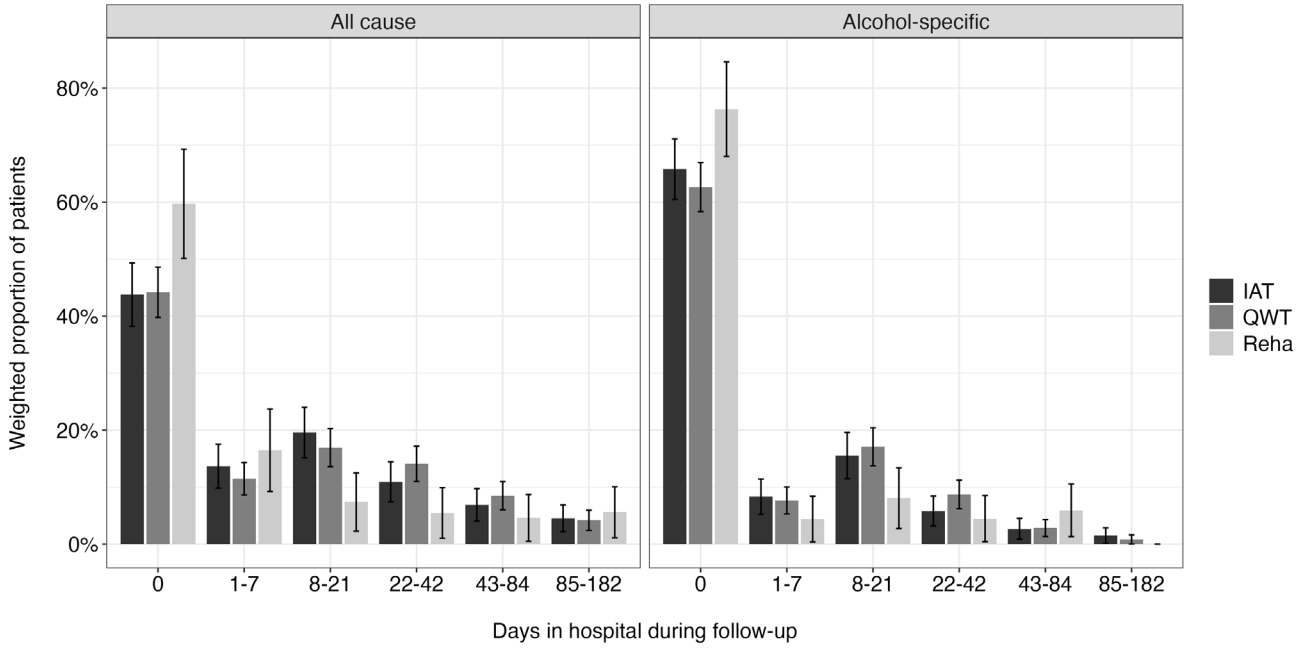

Figure 3. Weighted, unadjusted distributions of days in hospital during 12-months follow-up. Error bars indicate 95 % confidence intervals. IAT: inpatient alcohol treatment. QWT: qualified withdrawal treatment only. Reha: qualified withdrawal treatment with subsequent rehabilitation treatment.

up among patients with QWT and subsequent rehabilitation treatment was statistically significantly higher compared to those receiving QWT only (p=.032). Relying on the inverse of the OR, entering rehabilitation treatment after QWT decreased the odds for any alcohol-specific hospitalisation by 47% (OR=1/1.87=0.53). For each additional day between first diagnosis and treatment, the odds of any alcohol-specific hospitalisation subsequent to the treatment increases by 0.3% (1.003=1/0.997). Among those hospitalised for alcohol-specific causes, there was no statistically significant difference in the number of days in hospital between the two groups (p>.050). Excluding patients with irregular discharge yielded similar results with slightly higher effect sizes for rehabilitation treatment in the zero component (OR=2.04, 95% CI [1.16–3.53]; see ESM 4).

Simulating Increases in Rehabilitation Treatment

Figure 4 depicts the estimated proportion of AUD patients without any re-hospitalisation during 12-months follow-up, if 20%, 35%, and 50% of patients would enter rehabilitation treatment (see ESM 6 for detailed results). In the reference scenario, 45.8% (95% CI [42.6–48.9%]) and 65.2% (95% CI [62.2–68.1%]) of all 894 patients receiving any treatment had zero all-cause and alcohol-specific inpatient stays during 12-month follow-up, respectively. This proportion increased gradually to up to 50.7% (95% CI [47.5–53.9%]) and 69.2% (95% CI [66.2–72.1%]) in a simulation scenario where every second AUD patient in IAT and QWT would receive subsequent rehabilitation treatment. In this scenario, there were an estimated 44 (all-cause) and 35 (alcohol-specific) additional AUD patients without any hospitalisation during follow-up. Based on an average of 19 (all-cause) and 15 (alcohol-specific) days in hospital for those who have been re-hospitalised (weighted median), an estimated 836 and 525 inpatient days due to all and alcohol-specific causes could have been avoided, respectively.

Discussion

In this data linkage study, we found that QWT with subsequent rehabilitation treatment is associated with statistically significant reductions in all-cause and alcohol-specific re-hospitalisation during 12-months follow-up. Comparing IAT with QWT only, no differences in re-hospitalisation rates were observed. Thus, we can confirm our hypothesis that post-acute treatment is key to improving the health of patients with AUD. Providing more AUD patients with rehabilitation treatment could avoid a relevant number of re-hospitalisations within 12-months after treatment completion.

Limitations

Several caveats need to be considered in the interpretation of our findings. First, the detailed insurance data that was analysed in this study is routinely collected for administrative and reimbursement purposes. These data may therefore not primarily be used to ascertain accurate diagnoses, which may increase the risk of misclassification, and does not include any detailed information about specific interventions offered to the patients. However, to account for these limitations inherent in the data, we applied strict inclusion criteria and employed definitions of diagnosis and treatments used in prior studies (e.g., [Epping et al., 2024]).

Second, while we differentiated QWT from IAT using OPS codes, the exact therapeutic components of both treatments remain unclear. This may have prevented us from detecting a beneficial health effect of QWT over IAT, as reported in other studies (Koopmann et al., 2024). Moreover, the average treatment duration of the QWT only group was 15 (IQR: 10–21) versus 21 days in the group with subsequent rehabilitation treatment. Using logistic regression, we found that patients with full-length QWT (i.e., 21 days) had statistically significantly higher odds of

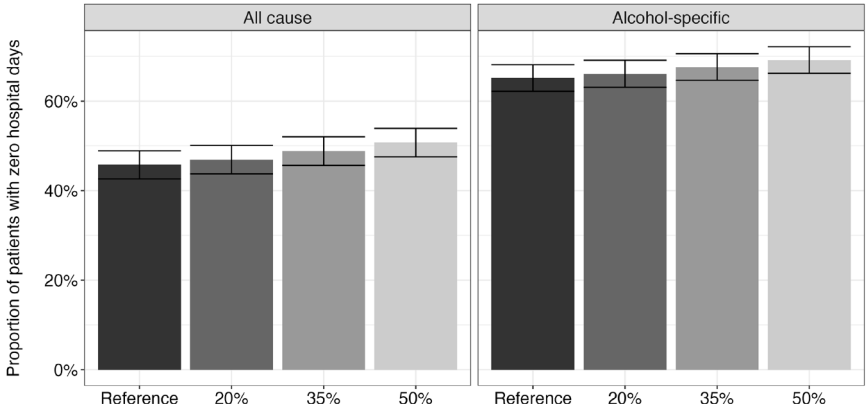

Figure 4. Estimated proportion of AUD patients with zero hospital days during 12-months follow-up under different simulation scenarios: Reference (11%), 20%, 35%, and 50% of AUD patients with rehabilitation treatment.

receiving rehabilitation treatment following QWT compared to those with a shorter treatment duration (OR = 2.14, 95 % CI [1.31–3.48], see ESM 5). Patients with full-length QWT may have been more likely to be referred to rehabilitation treatment, which in turn was associated with lower odds of re-hospitalisation. To address this potential bias, we repeated our main analysis excluding patients with irregular discharge from IAT or QWT (see ESM 4). The findings from this sensitivity analysis confirmed our main results and strengthened our confidence in the findings. Residual confounding is another bias that could potentially explain the superiority of rehabilitation treatment, for example, if people seeking rehabilitation treatment use lower amounts of alcohol or have a less severe form of AUD. We addressed this bias using matching weights; however, residual confounding cannot be ruled out completely.

Third, our study population is restricted to individuals who have been insured by two of the largest SHIs in the city-state of Hamburg, Germany. Notably, certain populations with a disproportionately high alcohol-related health burden, such as individuals experiencing homelessness and lacking health insurance (Bertram et al., 2022), may not be represented in the sample. Moreover, our results may only be of limited generalisability to other regions of Germany, as regional differences in healthcare coverage and provision exist. For example, the city-state of Hamburg ranks above average of available hospital beds per 1.000 population (in 2022: 6.8 vs. 5.7 per 1.000 population; [Statistische Ämter des Bundes und der Länder, 2024]), indicating higher capacities for inpatient treatment compared to other regions. Lastly, as the insurance data were only available for a six-year period, we cannot preclude the existence of AUD diagnoses or the impact of interventions received prior to the observation period and cannot assess the long-term impact of interventions.

Implications

Rehabilitation is one of many forms of post-acute interventions available for people with AUD in Germany (Bürkle et al., 2019). Our findings suggest that acute care, e.g., QWT, should be followed by post-acute care, e.g., rehabilitation treatment, to improve the overall health of AUD patients. Rehabilitation treatment seeks to maintain, improve, and restore the functional and productive capacities of patients with AUD and to facilitate their participation in work and social life (Kiefer et al., 2021). This long-term treatment also enables patients to receive psychotherapy, the treatment of comorbidities, and the development of long-term strategies for maintaining abstinence, which is the primary treatment goal and likely to show the largest health benefits in the mid- and long-term (Schwarzinger et al., 2024). However, it should be noted that only a small proportion of AUD patients entered rehabilitation treatment in our sample (i.e., 573 of 7,248; 7.9 %, see Figure 1), with long waiting times, limited treatment capacities, and structural barriers potentially preventing patients from receiving this treatment (Wolfe et al., 2023). Our results suggest that increasing rehabilitation treatment rates could significantly lower re-hospitalisation in the year following the treatment, albeit to a moderate extent only. Additional costs associated with increasing treatment coverage may be contrasted with the potential medium- and long-term savings due to prevented additional hospital stays, chronic disease progression, and premature death. Further studies with longer follow-up periods are needed for a comprehensive and differentiated assessment of the (cost-)effectiveness of rehabilitation treatments for patients with AUD.

In contrast, QWT without subsequent rehabilitation treatment was not associated with an overall health improvement over IAT in our study. As both IAT and QWT are acute treatments, they may only be a first step in a treatment cascade by reducing the acute effects of alcohol (e.g., symptoms related to alcohol withdrawal) and, in the case of QWT, strengthening the willingness and ability to behavioural change (Kiefer et al., 2021). To achieve measurable health improvements, however, post-acute treatment appears to be more relevant to address underlying (mental) health conditions and comorbidities and to develop strategies for maintaining abstinence. This is particularly relevant as relapse rates are high even after completing rehabilitation treatment, with about two in three patients having at least one relapse (Bachmeier et al., 2024).

In our sample, only about 1 in 3 patients in QWT were in treatment for 21 days or longer, as recommended in the guidelines (Kiefer et al., 2021). A recent study reported an average of 19 days in QWT (Koopmann et al., 2024) – higher than in our sample (median: 15 days). If the majority of patients in QWT did not benefit from the extensive psychosocial support integrated in this form of therapy, this could be one reason for not finding any statistically significant differences in re-hospitalization rates between IAT and QWT groups. Further analysis showed that a longer QWT predicts the uptake of rehabilitation treatment. This could possibly be explained by the fact that a longer QWT allows the psychosocial team to prepare for the transition to rehabilitation treatment more effectively. Overall, these findings reiterate that continuous care is key to improving health of people with AUD (Lee et al., 2014).

In summary, our findings suggest that AUD patients suffering from severe alcohol-related symptoms and/or poor physical or mental health should be offered rehabilitation treatment following QWT. Expanding the provision and

utilisation of rehabilitation treatment will likely reduce the immediate, detrimental health outcomes of AUD and may lower their risk of re-hospitalisation. This is particularly important, as alcohol-specific mortality has increased in Germany during the COVID-19 pandemic despite declines in overall alcohol consumption levels (Kilian et al., 2023). Efforts must be taken to ensure that patients receive the appropriate treatment for their individual needs. Among others, this requires the training of healthcare professionals, especially in primary care settings, as well as the elimination of structural barriers of treatment access. Last, more research is needed to understand treatment pathways of AUD patients and to evaluate treatment effectiveness, especially in the case of QWT, to improve the physical and mental health of patients, as there is a substantial lack of empirical research and treatment guidelines are largely based on clinical consensus (Kiefer et al., 2021).

Electronic Supplementary Material

The Electronic Supplementary Material (ESM) is available with the online version of the article at https://doi.org/10.1024/0939-5911/a000962.

ESM 1. Departures from the study plan.

ESM 2. Establishing comparability between treatment samples.

ESM 3. Distribution of outcome variables.

ESM 4. Sensitivity analysis excluding patients with irregular discharge.

ESM 5. Association between lengths of qualified withdrawal treatment and receiving subsequent rehabilitation treatment.

ESM 6. Results of modelling an increase in rehabilitation treatment.

ESM 7. References.

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Open Data
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