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Prevalence Estimates of ADHD in a Sample of Inpatients With Alcohol Dependence

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Abstract

Objective: ADHD is common in patients with alcohol dependence, but prevalence results are inconsistent. We investigated ADHD prevalence in a complex design to avoid over- or underdiagnosing. **Method:** Patients with alcohol dependence starting long-term residential treatment were included. A structured interview (Diagnostic Interview for ADHD in Adults [DIVA]) was conducted on all patients. DIVA results indicating childhood *or* adulthood ADHD were assessed in successive diagnostic interviews by two expert clinicians. **Results:** 415 of 488 patients had completed the entire diagnostic assessment. ADHD prevalence was 20.5%. DIVA results correlated moderately with experts' diagnoses. In patients with ADHD, a higher comorbid illicit substance use was prevalent and alcohol dependence started earlier and was more severe. **Conclusion:** This study provides the largest sample on ADHD prevalence in alcohol dependent inpatients. Despite great efforts to avoid overestimation, we found every fifth patient to have ADHD. ADHD diagnosis should not be based solely on a structured interview but should be clinically confirmed. *(J. of Att. Dis. 2020; 24(14) 2072–2083)*

Keywords

dual disorder, structured interview, alcohol, substance related disorders

Introduction

ADHD and Substance Use Disorders (SUDs)

ADHD is common but often underrecognized (Huntley et al., 2012; McAweeney, Rogers, Huddleston, Moore, & Gentile, 2010) in patients with SUD. Comorbid ADHD in SUD patients has a negative impact on SUD treatment efficacy and treatment retention (Arias et al., 2008; Carroll & Rounsaville, 1993; Ercan, Coskunol, Varan, & Toksoz, 2003; Wilens & Morrison, 2011) and is associated with a more severe course of substance use, social, and psychiatric impairment (Moura et al., 2013).

ADHD during childhood or adolescence increases the risk for developing an alcohol use disorder (AUD) or other SUDs (Lee, Humphreys, Flory, Liu, & Glass, 2011; Wilens & Morrison, 2011). Also, ADHD is a risk factor for heavy alcohol use and initiation of illicit drug use in young adults (Vogel et al., 2016). Some studies have suggested that this increased risk can be explained by shared genetics (Capusan, Bendtsen, Marteinsdottir, Kuja-Halkola, & Larsson, 2015; Edwards & Kendler, 2012), while psychological factors may also contribute to enhance the risk for substance use: (emotional) impulsivity (De Alwis, Lynskey, Reiersen, & Agrawal, 2014; Pedersen et al., 2016; Roberts, Peters, Adams, Lynam, & Milich, 2014) and aversion to delay gratification (Wickens & Tripp, 2005) as well as neuroticism and anxiety (Davis, Cohen, Davids, & Rabindranath, 2015) may mediate between ADHD symptoms and early inclination toward substance use.

ADHD has a worldwide prevalence in the general population of 3.4% in childhood and adolescence (Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015) and of 2.5% in adults (Simon, Czobor, Balint, Meszaros, & Bitter, 2009). In the AUD population, prevalence is increased with reported prevalence rates ranging from 6.6% to 21.3% (Daigre et al., 2015; Johann, Bobbe, Putzhammer, & Wodarz, 2003; Ohlmeier et al., 2008; Reyes et al., 2019; Roncero et al., 2019; van de Glind et al., 2014).

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Diagnosing ADHD in Patients With SUD

Structured interviews for the diagnostic assessment of ADHD in SUD populations are frequently used but have not yet been validated for this group (Ramos-Quiroga et al., 2019). However, withdrawal and intoxication symptoms or psychological consequences from chronic substance use (i.e., substance-induced disorders) might interfere with the diagnostic process. Furthermore, early abstinence in AUD is also associated with increased symptoms of depression and anxiety, sleep disturbances, increased sensitivity to stress, anhedonia, and emotional dysregulation (Heilig, Egli, Crabbe, & Becker, 2010; Spanagel, Noori, & Heilig, 2014). Furthermore, this period is associated with a hypodopaminergic state in humans and rodents and with increased motor activity in animal models (Hirth et al., 2016). Hence, observed symptoms might be wrongly attributed to SUD, other psychiatric disorders, or ADHD. Therefore, the longitudinal aspect of ADHD as a nonepisodic disorder and the association of ADHD symptoms with periods of abstinence or substance use have to be taken into account carefully (Levin & Upadhyaya, 2007; Ramos-Quiroga et al., 2019; Sullivan & Rudnik-Levin, 2001). Moreover, novelty of the therapeutic setting, sobriety by itself, and initiation of psychotherapy may initially aggravate affective instability and stress sensitivity. Thus, an extended period of stabilization during prolonged abstinence might be required to unequivocally assess ADHD symptoms in AUD patients.

Aims of This Study

We conducted a study on ADHD prevalence in alcohol dependent patients that takes sufficient account of the risk of under- and overdiagnosing ADHD: (a) instead of relying solely on a structured interview, ADHD diagnosis had to be confirmed clinically by two experts in the field; (b) the diagnostic process started several weeks after hospital admission to exclude interference with intoxication, (prolonged) withdrawal, or chronic substance use symptoms and to ensure emotional, mental, and social stabilization in a residential long-term treatment setting; (c) a great amount of additional information on childhood and current ADHD symptoms was gathered (school records, parent ratings, behavior during treatment, ratings of close friends/relatives); and (d) the residential long-term treatment setting resulted in low treatment discontinuation and study dropout rates which allowed to fully assess the majority of patients over the course of many weeks.

Method

At the addiction treatment center MEDIAN Klinik Wilhelmsheim, Germany, approximately 750 patients (age >18 years) with alcohol dependence are treated per year in a residential setting after elective admission, each treatment lasting 8 to 16 weeks. Relapse and early discharge are rare events and patients are required to be abstinent on admission.

Study Design

The study had no external funding and was approved by the local ethics committee. Main inclusion criteria were written informed consent and a diagnosis of alcohol dependence according to International Statistical Classification of Diseases and Related Health Problems–10 (ICD-10; World Health Organization, 1993). Exclusion criteria were serious cognitive deficits. The study design is illustrated in Figure 1. All patients received information on the study and ADHD in a group setting before informed consent was obtained. After 4 to 5 weeks of inpatient treatment, a structured interview on ADHD (Diagnostic Interview for ADHD in Adults–2.0 [DIVA-2.0]) was conducted by two medical doctors. DIVA is free of charge and available in many different languages including German (J. J. S. Kooij, 2012). DIVA uses the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association [APA], 1994) ADHD criteria for childhood and adulthood and elucidates ADHD criteria with different examples. The interview takes 45 to 90 min.

Preventing Over- and Underdiagnosing of ADHD

To ensure that administration of DIVA would not lead to *overdiagnosis*, two experts in the field of ADHD/SUD, each with several years of clinical expertise in psychiatry and addiction medicine and specialized in diagnosing and treating comorbid ADHD, had to clinically confirm each suspected ADHD diagnosis made by DIVA in successive nonstructured clinical interviews.

When diagnosing ADHD during adulthood, *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; APA, 2013) requires five or more symptoms of inattention and/or hyperactivity–impulsivity and "several" symptoms before the age of 12 retrospectively. When diagnosing ADHD during childhood or adolescence, six or more symptoms are needed. Irrespective of the time of diagnosis, *DSM-IV* requires six or more symptoms both for adults and children prior to 7 years of age. To ensure that administration of DIVA would not lead to *underdiagnosis*, we lowered the diagnostic threshold for suspicious DIVA below *DSM-IV* and *DSM-5* criteria. In this study, only four or more symptoms in at least one cluster during adulthood or five or more symptoms in at least one cluster during childhood were sufficient to initiate further diagnostic assessment. Hence, persisting ADHD symptoms from child- to adulthood were not required for further diagnostic assessment. In a stepwise approach, Expert 1 would see all patients with suspicious

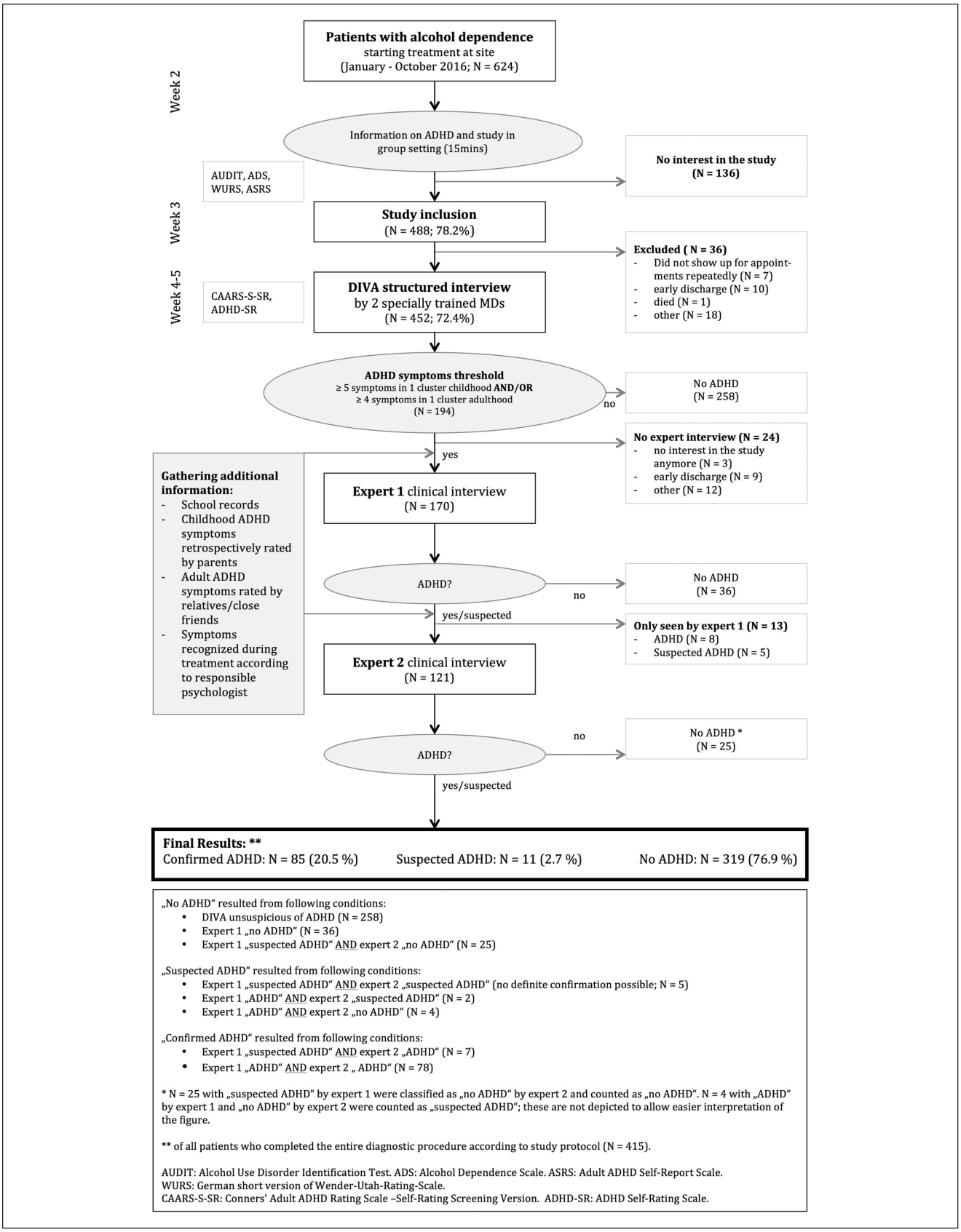

Figure 1. Study design and diagnostic process.

Table 1. Additional Information Resources for ADHD Symptoms.

Self-rating childhood ADHD symptoms	• German short version of the Wender Utah Rating Scale (Retz-Junginger et al., 2003; Ward, Wender, & Reimherr, 1993)
Self-rating adulthood ADHD symptoms	• Conners' Adult ADHD Rating Scale–Self-Rating Screening Version (Conners, Erhardt, & Sparrow, 1999) • Adult ADHD Self-Report Scale v1.1 (ASRS; Kessler et al., 2005) • ADHD Self-Rating Scale (Rosler et al., 2004)
Informant rating childhood ADHD symptoms	• Parent Rating Scale (Krause, Krause, & Trott, 1998; Wender, 1995) • School records for the age of 6 to 12 years
Informant rating adulthood ADHD symptoms	• Close friends/relatives: Conners' Adult ADHD Rating Scale–Informant Rating Screening Version (Conners et al., 1999) • If ADHD had been diagnosed before, medical records were reviewed.
Information from responsible psychologists during residential treatment	• Patient's performance and behavior (nonstructured) • ADHD diagnostic checklist (Rosler et al., 2004)

DIVA results whereas Expert 2 would only see patients deemed suspicious of ADHD by Expert 1. If Expert 1 rejected ADHD diagnosis, Expert 2 would not additionally interview these patients.

The experts used a three-staged scoring system ("no ADHD," "suspected ADHD," "ADHD"). The diagnostic verdict of Expert 1 was available to Expert 2. If experts' opinions did not match, cases were discussed. If a unanimous decision could not be made, ADHD was not diagnosed (see Figure 1).

Performance of the Structured Interview

Experts' diagnoses were compared with DIVA for those patients who had suspicious DIVA results (with the lowered threshold mentioned above) and had received the required expert interviews according to protocol. This allows an estimation of DIVA's performance in AD patients. For this purpose, we correlated experts' diagnoses with DIVA results at different cutoffs for number of symptoms per cluster (hyperactivity/impulsivity or inattention) in childhood and adulthood.

Additional Sources of Information

An extensive amount of additional information was gathered (Table 1). These resources were considered in the experts' clinical diagnostic assessment. The following collateral data were obtained: structured information from clinical staff (n = 149), informants' ratings adulthood (n = 126), parents ratings of childhood (n = 91), and school records (n = 53).

Other Variables Assessed

Substance use and SUD diagnoses according to ICD-10 were routinely assessed at treatment initiation. Demographic data and other diagnoses were retrieved from patients' files.

Two questionnaires regarding alcohol addiction were completed during the second week after admission. The Alcohol Dependence Scale (ADS) is a self-rating instrument to assess severity of alcohol dependence (Skinner & Horn, 1984). The Alcohol Use Disorders Identification Test (AUDIT) is a widely used screening test to identify problematic alcohol consumption (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993).

Alcohol abstinence was verified by regular alcohol breath tests: Each day, a random selection of 40 patients (number of hospital beds: 214) was assessed. In addition, alcohol breath tests, urine ethyl glucuronide (EtG), and urine toxicology for illicit drugs, opioids, and benzodiazepines were conducted on a regular base in certain patients or upon request from staff when patients were suspected of substance intake.

Statistical Analyses

Demographic and clinical characteristics, severity of alcohol dependence (AUDIT and ADS), and DIVA results were compared between groups (ADHD vs. no ADHD) using chi-square or Fisher's exact test and Mann–Whitney U tests. For comparison between DIVA and experts' diagnoses, Cohen's kappa was calculated for those patients who had suspicious DIVA results and completed diagnostic assessment per protocol. Values between 0.6 and 0.79 are considered moderate levels of agreement (McHugh, 2012). For all calculations, results with $p < .05$ were considered significant.

Results

Participants and Inclusion Rates

Study recruitment took place from January until October 2016. 488 of 624 admitted alcohol dependent patients (78.2%) agreed to participate in the study. In 36 patients, DIVA could not be conducted and patients were thus excluded from the study (Figure 1). Hence, 452 patients with alcohol dependence (72.4% of all admitted patients)

received a DIVA interview at 4 to 5 weeks after treatment initiation. 24 of 452 patients (4.6%) had suspicious DIVA results but were not further seen by any expert (Figure 1). Another 13 patients (2.9%) completed DIVA and one expert interview but the scheduled second expert interview was not conducted. In total, 415 of 488 patients (85%) completed the entire study according to protocol with one to three interviews spread out over several weeks. Mean time between DIVA and final expert interview was 24.7 ± 16.4 days (median = 22.0 ± 10.3; range = 4-105), resulting in an average period of approximately 8 weeks from admission to final diagnosis.

Study Dropout

24 patients had DIVA results indicating an expert interview (suspecting ADHD diagnosis) but no expert interview could be conducted. These patients who dropped out of the study directly after the DIVA interview showed significant differences in several variables (Supplementary Table 1) that resemble those of ADHD patients: They were significantly younger on admission, had a significantly younger age of onset of problematic alcohol use, had more drinking days on admission, had a higher relapse rate during treatment, and showed a higher frequency of any SUD (especially cannabis and polydrug use disorder).

Due to incomplete data, this analysis could not be executed for those patients who were excluded before DIVA.

ADHD Prevalence

In a strict per protocol analysis, only those study patients who had completed the entire diagnostic procedure (n = 415) were included. 85 patients (20.5%) were diagnosed with ADHD. Only five of these 85 (5.9%) patients had been diagnosed with adult ADHD prior to hospital admission, two of them receiving medical treatment with methylphenidate or atomoxetine on admission. All adult ADHD diagnoses known on admission were confirmed in our study. No additional patients with a known diagnosis of childhood or adolescent ADHD were identified in our study population. In 11 patients (2.7%), the diagnosis "suspected ADHD" resulted from either both experts not being able to confirm or reject ADHD (n = 5) or Expert 2 not being able to confirm the (suspected) ADHD diagnosis of Expert 1 (n = 6). Two patients were diagnosed with "late-onset" ADHD as they showed and reported typical ADHD symptoms and functional deficits in adulthood but had only few or no ADHD symptoms before the age of 12.

Performance of the Structured Interview

DIVA results were correlated with final ADHD diagnosis. For this analysis, patients with experts' diagnoses of "suspected ADHD" (n = 11) as well as patients who did not complete the diagnostic procedure as per protocol were excluded (n = 37). Thus, 146 patients who were above our self-defined threshold for suspicious DIVA results received expert interviews according to protocol. This analysis does not include the 258 patients whose DIVA scores were below our self-defined threshold, as no further diagnostic assessment was performed.

Depending on the chosen threshold values (Table 2), DIVA showed only moderate agreement with the experts' opinions (Cohen's Kappa = .514-.579). Agreement was best (Kappa = .579 and .563) when *DSM-5* criteria for adult ADHD (five or more symptoms in at least one cluster for adulthood) were applied together with four to five or more childhood symptoms in at least one cluster.

Substance Use Variables and ADHD

Substance use variables are shown in Table 3. The majority of patients with and without ADHD had been detoxified prior to hospital admission as required for residential rehabilitation treatment in Germany. Alcohol relapse during treatment occurred infrequently, but patients with ADHD relapsed twice as often (10.6% vs. 4.4%; p = .036). Patients with ADHD were significantly younger (41.4 vs. 49.3 years; p < .001) on admission but had the same duration of alcohol dependence (13.1 vs. 13.5 years; p = .681). Hence, alcohol dependence started at a younger age in patients with ADHD, who also showed a more severe alcohol dependence both in the ADS (18.6 vs. 12.7; p < .001) and AUDIT (28.5 vs. 25.0; p < .001). They also reported a higher rate of previous delirium tremens (14.1% vs. 6.0%; p = .012), but not of withdrawal seizures (15.3% vs. 15.2%; p = .611).

In patients with ADHD, tobacco use disorder started at an earlier age (16.2 vs. 18.1 years; p = .010). The rate of tobacco dependence was increased but did not reach statistical significance (80.0% vs. 69.3%; p = .052). Patients with ADHD also had a higher rate of comorbid drug use disorder (32.9% vs. 11.6%; p < .001), in particular cannabis (23.5% vs. 7.8%; p < .001), and a higher rate of past intravenous drug abuse (7.1% vs. 1.6%; p = .014).

Discussion

This study provides the largest sample on ADHD prevalence in AD inpatients reported so far. The prevalence rate of 20.5% in the present study is among the highest in the literature (Daigre et al., 2015; Johann et al., 2003; Ohlmeier et al., 2008; Reyes et al., 2019; Roncero et al., 2019; van de Glind et al., 2014; van Emmerik-van Oortmerssen et al., 2012) despite eliminating many of the usual risks that might lead to overdiagnosing ADHD.

Recent studies on ADHD prevalence in AD patients reported a broad range of 6.6% to 21.3% (Daigre et al.,

Table 2. Results of Structured ADHD Interview (DIVA) in Comparison With Experts' Diagnoses With Different Cutoff Values for Childhood and Adulthood Symptoms.

DIVA cutoff values	DIVA result	Experts' diagnoses: ADHD	Experts' diagnoses: No ADHD	Cohen's Kappa	Sens.	Spec.	PPV	NPV	*p*
Threshold for expert interview Childhood ≥5 symptoms in 1 cluster and/or Adulthood ≥4 symptoms in 1 cluster	DIVA above threshold	85	61	—	—	—	—	—	<.001**
DSM-IV	DIVA ADHD	66	14	.541	.78	.77	.83	.71	<.001**
Childhood ≥6 symptoms in 1 cluster and Adulthood ≥6 symptoms in 1 cluster	DIVA no ADHD	19	47						
DSM-5: Childhood 3	DIVA ADHD	78	26	.514	.92	.57	.75	.83	<.001**
Childhood ≥3 symptoms in 1 cluster and Adulthood ≥5 symptoms in 1 cluster	DIVA no ADHD	7	35						
DSM-5: Childhood 4	DIVA ADHD	77	22	.563	.91	.64	.78	.83	<.001**
Childhood ≥4 symptoms in 1 cluster and Adulthood ≥5 symptoms in 1 cluster	DIVA no ADHD	8	39						
DSM-5: Childhood 5	DIVA ADHD	77	21	.579	.91	.66	.79	.83	<.001**
Childhood ≥5 symptoms in 1 cluster and Adulthood ≥5 symptoms in 1 cluster	DIVA no ADHD	8	40						
DSM-5: Childhood 6	DIVA ADHD	71	18	.545	.84	.70	.80	.75	<.001**
Childhood ≥6 symptoms in 1 cluster and Adulthood ≥5 symptoms in 1 cluster	DIVA no ADHD	14	43						

Note. Patients with "suspected ADHD" (n = 11) as well as those who did not complete diagnostics by protocol (no expert interview: n = 24; no indicated second expert interview: n = 13) were excluded. Cohen's Kappa for ADHD versus no ADHD. Cells with false positive/false negative DIVA results are grayed out for reading comfort. DIVA = Diagnostic Interview for ADHD in Adults; Sens. = sensitivity; Spec. = specificity; PPV = positive predictive value; NPV = negative predictive value; *DSM-IV* = *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; APA, 1994); *DSM-5* = *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; APA, 2013); APA = American Psychiatric Association.
$p < .001$ (chi-square) for all combinations.** highly significant ($p < .01$).

2015; Ohlmeier et al., 2008; Reyes et al., 2019; Roncero et al., 2019; van de Glind et al., 2014). A large international multicenter study with 339 inpatients and 351 outpatients with AUD applied a structured interview for ADHD diagnosis (van de Glind et al., 2014) and found an ADHD prevalence rate of 7.5% (6% inpatients, 9% outpatients), with a high variability depending on country and setting with inpatient prevalence rates between 5% and 22%. In a smaller German trial, 91 alcohol dependent inpatients of a psychiatric clinic were included (Ohlmeier et al., 2008). Here, an adult ADHD prevalence rate of 6.6% was reported by solely applying a self-rating questionnaire to assess adult ADHD symptoms. Johann et al. (2003) used a self-rating questionnaire for childhood and an investigator rated checklist of ADHD symptoms for adulthood on a sample of alcohol dependent inpatients and found adult ADHD to be prevalent in 67 of 314 patients (21.3%). However, patients with major psychiatric disorders such as depressive disorders and those with comorbid addictions to drugs other than nicotine were excluded. Reyes et al. (2019) primarily included in- and outpatients with AUD. ADHD diagnosis was assessed by a structured interview and confirmed in 29 of 379 patients (7.7%). Roncero et al. (2019) conducted a structured interview performed by experienced clinicians on 297 patients with a lifetime diagnosis of alcohol dependence. By extrapolating the results of a screening questionnaire on a larger sample of 729 patients, an ADHD rate of 16.1% was estimated. One of the highest rates of ADHD (21.1%) in 355 outpatients with lifetime alcohol dependence was reported in a study (Daigre et al., 2015), which described the most extensive diagnostic work-up of all previous studies. It comprised three successive sessions and included a structured interview on ADHD and another on psychiatric comorbidities, and administration of questionnaires before diagnosis. This high prevalence rate compares well with our study, which also required three successive interviews for ADHD diagnosis and only included patients with prolonged alcohol abstinence. These results may indicate that a more in-depth

Table 3. Alcohol/Illicit Substance Use Variables for Patients With and Without ADHD Diagnosis (ADHD vs. No ADHD).

	ADHD (*N* = 85)		No ADHD (*N* = 319)		
	M/% (*n*)	*SD*	*M*/% (*n*)	*SD*	*p*
Age in years on admission	41.4	10.3	49.3	10.2	<.001**[a]
Gender in % male (*n*)	76.5% (65)		70.8% (226)		.305[b]
Duration of alcohol dependence in years	13.1	9.0	13.5	9.0	.681[a]
Age of onset of problematic alcohol use	25.3	9.3	31.9	12.1	<.001**[a]
Age of onset of alcohol use disorder	26.9	10.5	34.3	11.9	<.001**[a]
History of delirium tremens in % (*n*)	14.1% (12)		6.0% (19)		.012*[b]
History of withdrawal seizures in % (*n*)	15.3% (13)		13.2% (42)		.611[b]
Severity of alcohol dependence (ADS score)	18.6	6.9	12.7	6.5	<.001**[c]
AUDIT score	28.5	7.0	25.0	7.6	<.001**[c]
Drinking days (last 30 days before treatment initiation)	10.0	10.5	8.5	10.2	.219[a]
Tobacco use disorder in % (*n*)	80.0% (68)		69.3% (221)		.052[b]
Age of onset of tobacco use disorder	16.2	2.9	18.1	5.1	.010**[a]
Abstinence on admission in % yes	88.2% (75)		88.4% (282)		.966[b]
Substance relapse during treatment in % (*n*)	10.6% (9)		4.4% (14)		.036*[d]
Age of onset of any substance use disorder (including alcohol and nicotine)	19.5	9.1	23.3	11.6	.001[a]
Family history of substance use disorder in % (*n*) (parents, grandparents, siblings)	58.8% (50)		42.0% (134)		.006**[b]
Age of onset of drug use disorder (excluding alcohol and nicotine)	21.0	10.4	27.3	15.3	.252[a]
Intravenous consumption ever in % (*n*)	7.1% (6)		1.6% (5)		.014*[d]
Drug use disorder (except alcohol and nicotine) in % (*n*)	32.9% (28)		11.6% (37)		<.001**[b]
Amphetamine use disorder in % (*n*)	4.7% (4)		0.3% (1)		.008**[d]
Cannabis use disorder in % (*n*)	23.5% (20)		7.8% (25)		<.001**[d]
Sedative use disorder in % (*n*)	1.2% (1)		2.5% (8)		.691[b]
Opioid use disorder in % (*n*)	1.2% (1)		1.6% (5)		1.0[d]
Cocaine use disorder in % (*n*)	1.2% (1)		0.3% (1)		.377[d]
Polydrug use disorder in % (*n*)	8.2% (7)		1.6% (5)		.005**[d]

Note. Patients with diagnosis of "suspected ADHD" (*n* = 11) were excluded from analysis; use disorder = dependence or harmful use (ICD-10 F1x.2 or F1x.1); ADS = Alcohol Dependence Scale; AUDIT = Alcohol Use Disorder Identification Test; ICD-10 = International Statistical Classification of Diseases and Related Health Problems–10.

[a]Mann–Whitney *U*.

[b]Chi-square.

[c]The *t* test.

[d]Fisher's exact test.

*Significant ($p < .05$). **Highly significant ($p < .01$).

investigation for ADHD in abstinent AUD patients leads to a higher rate of ADHD, which would be missed otherwise.

In conclusion, heterogeneous inclusion and exclusion criteria and diagnostic procedures, different sample sizes and settings may have contributed to the high variability of reported ADHD prevalence in AUD patients in recently published studies.

The feasibility of diagnosing ADHD in patients still actively using substances was assessed by only one study. The authors could confirm >95% of the diagnoses after achieving abstinence (van Emmerik-van Oortmerssen et al., 2017). Nevertheless, it is of concern that substance use or (prolonged) withdrawal symptoms might inflate ADHD symptomatology in SUD patients (Levin & Upadhyaya, 2007; Ramos-Quiroga et al., 2019; Sullivan & Rudnik-Levin, 2001). Previous studies on ADHD prevalence in AUD either did not report on abstinence duration (Daigre et al., 2015; Johann et al., 2003) or required only short intervals of alcohol abstinence (Ohlmeier et al., 2008; Reyes et al., 2019) prior to ADHD assessment. Other studies only required intoxication and withdrawal symptoms to be absent at the time of ADHD assessment (Roncero et al., 2019; van de Glind et al., 2014). In contrast, the majority of patients in the present study were abstinent on admission. Together with a very low relapse rate that usually did not lead to treatment discontinuation, it is quite certain that substance use or withdrawal symptoms did not interfere with ADHD diagnosis, in particular as relapse was usually short in duration and diagnostic interviews were postponed under such circumstances. Furthermore, ADHD assessment was not completed with one single interview, but was a continuous process over several weeks and included a vast amount

of additional information (Table 1). Finally, the diagnostic process started only after 4 weeks of treatment, allowing the patients to extend their duration of abstinence, settle in the new hospital environment, and stabilize from the domestic psychosocial distress. This entire procedure allowed us to exclude symptoms of SUDs and other psychiatric comorbidities as reasons for ADHD symptoms. Hence, ADHD diagnosis in this study appears to be highly reliable.

Finally, most of the ADHD prevalence studies did not report on dropout rates (Daigre et al., 2015; Ohlmeier et al., 2008; Reyes et al., 2019; Roncero et al., 2019). This is of concern, as SUD patients with ADHD are at increased risk of treatment discontinuation and hence study dropout (Levin et al., 2004), which may lead to underestimation of ADHD prevalence, in particular if dropout rates are high. The largest ADHD prevalence study of SUD patients to date (van de Glind et al., 2014; van de Glind et al., 2013) reported a dropout rate of 48.9% in 2,595 patients. Of note, these dropouts exhibited a higher rate of positive scores on an adult ADHD self-rating questionnaire (Adult ADHD Self-Report Scale [ASRS]), which is suggestive of a higher ADHD prevalence rate in this subgroup. Although the diagnostic process in our study lasted several weeks, we noted low dropout rates and were thus able to fully assess a large proportion (85.7%) of all included patients.

Due to our high diagnostic completion rate, only a few patients were not fully assessed. Despite the small number of dropouts, we have found significant differences in some variables for those patients who dropped out of the study after DIVA. The patterns resemble those found in patients with ADHD versus patients without ADHD to some extent, which is not surprising, given the probably higher rate of ADHD in these patients with suspected ADHD diagnosis according to DIVA. Hence, ADHD prevalence rates could have been even higher if those patients had been fully assessed.

By only assessing a subsample of the primary population, a selection bias can lead to wrong prevalence estimations (Delgado-Rodríguez & Llorca, 2004). Our high study inclusion rate of 66.5% of all admitted alcohol dependent patients indicates a low risk for such selection bias and underlines the validity of our results.

Substance Use in Patients With ADHD

Patients with ADHD start their problematic substance use at a significantly younger age (Biederman et al., 2006; Chang, Lichtenstein, & Larsson, 2012; Young et al., 2015). They are younger when entering treatment but have the same duration of AD as patients without ADHD (Barkley, Fischer, Smallish, & Fletcher, 2004; King, Brooner, Kidorf, Stoller, & Mirsky, 1999; Kousha, Shahrivar, & Alaghband-Rad, 2012). Patients with ADHD are more severely affected by AD, have a higher rate of comorbid SUD (Huntley et al., 2012; Kousha et al., 2012), and show an increased relapse rate (Ercan et al., 2003; Wilens, Biederman, & Mick, 1998). All these findings were replicated in our study, which indicates that our study population of residential rehabilitation patients is comparable with other samples of treatment seeking AUD patients.

Children and adolescents with ADHD are at increased risk for smoking and tobacco use disorder (Chang et al., 2012), and tobacco use increases the risk for other SUDs, which is even more pronounced in patients with ADHD (Biederman et al., 2006). In our study, patients with ADHD had a significantly earlier onset of tobacco use disorder and a higher prevalence of tobacco dependence ($p = .052$).

In our study, patients with ADHD showed an increased rate of positive family history for SUD. This has been reported before (Yule, Wilens, Martelon, Simon, & Biederman, 2013) and has led to the hypothesis that genetic risk factors for SUD and ADHD overlap (Yule et al., 2017).

In accordance with previous studies, we delineate a severely impaired subgroup of AD patients with previously undiagnosed ADHD which present with early onset alcohol and other substance use, greater severity of alcohol dependence, higher comorbidity with other SUDs, and a higher relapse rate during treatment.

DIVA in AUD Patients

Structured interviews are often used in scientific and clinical settings and are usually validated by comparing their results with the results of experienced clinicians using official (e.g., *DSM-5*) criteria. This study is the first in AD patients that compares ADHD diagnosis from a structured interview with experts' clinical diagnosis. Of note, clinicians evaluated not all patients with DIVA interviews but only those who fulfilled the self-defined threshold criteria for suspicious ADHD, which are considerably lower than the diagnostic thresholds defined by *DSM-IV* and *DSM-5*. Hence, we clinically assessed more patients with suspected ADHD from DIVA ($n = 146$) than if we had followed *DSM-IV* ($n = 80$) or *DSM-5* criteria ($n = 89$-104, depending on number of childhood criteria required).

Results from DIVA showed moderate agreement with clinical ADHD diagnoses. A previous study using clinical expert's diagnosis as gold standard found a better performance for DIVA, but was conducted on a non-SUD sample (Pettersson, Soderstrom, & Nilsson, 2018). In our study, applying *DSM-5* criteria for adulthood (five or more symptoms) and five childhood symptoms showed superior results compared with the stricter *DSM-IV* criteria (six or more for both adult- and childhood). Adult ADHD patients often have trouble remembering their childhood symptoms (Miller, Newcorn, & Halperin, 2010), which might be even more pronounced in patients with SUD. A too strict

threshold for retrospective childhood symptomatology might therefore lead to an underestimation of ADHD.

Adults with ADHD tend to underreport their current ADHD symptoms (Sibley et al., 2012), as they exhibit low self-perception and self-awareness (Manor et al., 2012), are less able to link ADHD symptoms to impairments (Morstedt, Corbisiero, Bitto, & Stieglitz, 2015), and often compensate their deficits to some extent, which masks their symptoms and makes it more difficult to diagnose ADHD (Adler & Cohen, 2004; Culpepper & Mattingly, 2008; Kalbag & Levin, 2005). This pattern of underreporting symptoms occurs in children with ADHD as well and has been described as typical for ADHD (Owens, Goldfine, Evangelista, Hoza, & Kaiser, 2007). Hence, successive diagnostic interviews over the course of several weeks as performed in the present study might have led to improved introspection regarding ADHD symptoms in patients over time, which could partly explain the differences between the initial DIVA results and the subsequent experts' results. Also, many of the additional information sources (e.g., school records, parents' rating scales) were only available to the experts. Several guidelines emphasize the fact that ADHD diagnosis should be based on as many sources as possible (American Academy of Pediatrics, 2011; Kalbag & Levin, 2005; S. J. Kooij et al., 2010; National Collaborating Centre for Mental Health, 2009), which is supported by our study results.

According to our results, DIVA can be used in AD patients to assess ADHD symptomatology yet is accompanied by a significant rate of false negative and false positive results necessitating additional assessment by experienced clinicians. As DIVA previously showed a 100% agreement with another commonly used structured interview (Ramos-Quiroga et al., 2019), a careful interpretation of the results of structured ADHD interviews in the SUD population appears to be warranted in general.

Conclusion

The high prevalence of previously undiagnosed ADHD in every fifth alcohol dependent patient in residential alcohol treatment is highly relevant for the diagnostic assessment and therapy. It ought to encourage AUD treatment facilities to implement standard diagnostic procedures for all admitted patients to reliably identify undiagnosed ADHD. As there are both effective psychotherapeutic and medical treatment options available for patients with ADHD with comorbid SUD (Aviram, Rhum, & Levin, 2001; Grant et al., 2015; van Emmerik-van Oortmerssen, Vedel, van den Brink, & Schoevers, 2015; Wilens et al., 2008), identification of this large subgroup of severely impaired AD patients will hopefully lead to optimized treatment strategies with improved treatment outcomes for both AD and ADHD.

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