

UC Berkeley

UC Berkeley Previously Published Works

Title

Life-time history of insomnia and hypersomnia symptoms as correlates of alcohol, cocaine and heroin use and relapse among adults seeking substance use treatment in the United States from 1991 to 1994

Permalink

<https://escholarship.org/uc/item/8k08j3m1>

Journal

Addiction, 112(6)

ISSN

0965-2140

Authors

Dolsen, Emily A
Harvey, Allison G

Publication Date

2017-06-01

DOI

10.1111/add.13772

Peer reviewed



Published in final edited form as:

Addiction. 2017 June ; 112(6): 1104–1111. doi:10.1111/add.13772.

Lifetime history of insomnia and hypersomnia symptoms as correlates of alcohol, cocaine, and heroin use and relapse among adults seeking substance use treatment in the United States from 1991 to 1994

Michael R. Dolsen¹ and Allison G. Harvey¹

¹Department of Psychology, University of California, Berkeley, USA

Abstract

Aims—To examine the association between a lifetime history of insomnia and hypersomnia compared with no sleep disturbance and substance use patterns and amounts before and after a substance use treatment episode.

Design—Secondary analysis of data from the Drug Abuse Treatment Outcome Studies conducted from 1991 to 1994.

Setting—Data were collected at 96 substance use treatment programs in 11 United States cities including short-term in-patient, long-term residential, methadone maintenance, and outpatient drug-free treatment modalities.

Participants—Study samples included 7,168 adults at treatment entry and 2,965 at 12 months post-treatment entry whose primary substance use at entry was alcohol (14.7%), cocaine (62.7%), or heroin (22.6%).

Measurements—Lifetime history of insomnia and hypersomnia was assessed via self-report. Type and frequency of substance use were assessed at treatment entry. Substance use was also assessed 12 months following treatment completion. Associations were examined using linear and logistic regression with age, sex, race, education level, depression history, treatment modality, and in-treatment substance use as covariates.

Findings—Lifetime history of insomnia, hypersomnia, both or neither was reported by 26.3%, 9.5%, 28.0% and 36.2% of participants, respectively. Compared with no sleep disturbance, lifetime insomnia and hypersomnia were associated at treatment entry with unique substance use patterns and a higher frequency of any substance use ($p < .001$). All types of sleep disturbance were associated with higher rates of cocaine use at 12-month post-entry (ORs: 1.30–1.57).

Conclusions—There is evidence of an adverse association between substance use and sleep disturbance including higher frequency of all substance use before substance abuse treatment and higher rates of cocaine use after a treatment episode.

Corresponding Author: Allison G. Harvey, University of California, Berkeley, Department of Psychology, 2205 Tolman Hall #1650, Berkeley, CA 94720-1650. Phone: (510) 642-7138, aharvey@berkeley.edu.

Conflict of Interests: None.

Keywords

Sleep; Insomnia; Hypersomnia; Substance use; Substance use treatment; Relapse; Alcohol; Cocaine; Heroin

Introduction

Substance use is a major public health concern that interferes with mental and physical health, as well as overall functioning. Substantial evidence indicates that substance use and sleep disturbance are related, and that this relationship is likely bidirectional (1–8). Although many substances are associated with initial stimulatory or soporific effects (9), chronic substance use severely impairs sleep duration and quality, especially during periods of withdrawal. Additionally, despite the availability of effective treatments for sleep disturbance, there is evidence that illicit substances may be used in an attempt to alleviate sleep problems (10–12). Accordingly, sleep disturbance in the context of substance use is an important research focus, with potential implications for understanding and treating substance use and preventing relapse.

The relationship between sleep disturbance and substance use is complex in that substance use has been associated with both insomnia and hypersomnia. Insomnia is a widespread problem that affects one-third of the general population (13,14). Insomnia includes problems initiating and maintaining sleep, and specifically includes impairment related to difficulty falling asleep, staying asleep, or waking earlier than intended (15). Among individuals with insomnia, 30.0% also meet diagnostic criteria for comorbid alcohol use disorder and 14.4% experience comorbid substance use disorder (16). Insomnia is also associated with higher odds of meeting criteria for alcohol use disorder (OR=2.0, 95% CI [1.3–3.0]) and substance use disorder (OR=2.1, 95% CI [1.2–3.5]; (16). These results are consistent with, albeit higher than, comorbidity estimates from the NIMH Epidemiological Catchment Area program. Ford and Kamerow (17) reported that among individuals with insomnia, 7.0% also experience comorbid alcohol use disorder and 4.2% experience comorbid substance use disorder.

Hypersomnia involves daytime sleepiness or fatigue, daytime naps or sleep periods, protracted sleep periods (9 or more hours) that feel unrefreshing, and sleep inertia (15). Hypersomnia is associated with higher odds of alcohol use disorder (OR=2.9, 95% CI [1.7–4.8]) and substance use disorder (OR=3.6, 95% CI [2.0–6.4]) (16). Additionally, among individuals with hypersomnia, 36.1% meet criteria for alcohol use disorder and 22.9% meet criteria for substance use disorder (16). However, comorbidity estimates from the NIMH Epidemiological Catchment Area program are comparatively lower with 6.2% of individuals having both hypersomnia and alcohol use disorder and 4.7% of individuals having both hypersomnia and substance use disorder (17).

The relationship between sleep disturbance and substance use also appears to depend on the type of substance used (6–8), most notably between substances such as alcohol, cocaine, and heroin. There is strong evidence that sleep disturbance and alcohol are related. In particular, insomnia is present during various phases of alcohol use (10,18–20), and alcohol is

reportedly used by 45% of patients with alcohol dependence as self-medication for sleep problems (10). Additionally, cocaine is associated with longer sleep onset latency and decreased sleep efficiency compared to age-matched controls as measured by polysomnography (21). The first four days of cocaine withdrawal are initially associated with insomnia symptoms, but then followed by increased desire for sleep and hypersomnia (22). Notably, 80% of individuals with increased desire for sleep during early-phase cocaine withdrawal self-medicated with alcohol and opiates (22). Although there is less data on sleep disturbance and heroin, both objective and subjective sleep disturbance, including insomnia symptoms, are related to heroin use (3,23–27).

Sleep disturbance may also be a risk factor for substance use relapse (28). Insomnia symptoms, and long sleep onset latency in particular, have been consistently linked to alcohol use relapse (10,29,30). There is also a growing literature on the relationship between sleep and cocaine relapse. A recent report found evidence that improvements in slow-wave sleep mediated the relationship between modafinil treatment and a higher rate of cocaine abstinence (31). Further, sleep disturbance has been linked to cocaine cravings after long-term withdrawal in rats, which could increase the likelihood of relapse (32). Less research has examined if hypersomnia or insomnia are prospectively related to heroin relapse (see similar conclusion in Brower & Perron, 2010). However, there is evidence that improvements in sleep problems may predict abstinence in opioid-dependent patients (33). Additionally, an experience sampling study also provided evidence that poorer sleep quality is related to more drug cravings among patients in residence for substance treatment (34). These findings highlight the importance of sleep disturbance in the context of substance use relapse. To the best of our knowledge, studies have not yet sought to systematically examine the role of insomnia or hypersomnia symptoms on substance use relapse in the context of a large, community-based substance use treatment study.

The aim of the present study was to test the hypothesis that adults seeking substance use treatment in the United States from 1991 to 1994 that report a lifetime history of insomnia symptoms, hypersomnia symptoms, or both insomnia and hypersomnia symptoms will have differing patterns of alcohol, cocaine, and heroin use compared to no sleep disturbance. This study will also test the hypothesis that individuals that reported a lifetime history of insomnia symptoms, hypersomnia symptoms, or both insomnia and hypersomnia symptoms at pre-treatment will use substances more frequently than individuals that reported no sleep disturbance symptoms. Last, this study will test the hypothesis that individuals that reported a lifetime history of insomnia symptoms, hypersomnia symptoms, or both insomnia and hypersomnia symptoms will be more likely to use alcohol, cocaine, and heroin 12-months post-treatment.

Methods

Design

Data come from the Drug Abuse Treatment Outcome Study (DATOS), which was a multisite prospective study on community-based substance use treatment from 96 programs in 11 United States cities from 1991 to 1994. The methods employed by DATOS are described elsewhere (35). Participants were included in this sample if sleep data was available and the

primary substance use problem was alcohol (n=1,057), cocaine (n=4,494), or heroin (n=1,617). This resulted in 7,168 adults (2,451 female, mean age=32.8) with data at treatment entry. A follow-up sample was randomly selected from participants who completed the pre-treatment intake interview (35,36). Participants were interviewed 12-months after treatment termination, or 24-months after treatment termination for long-term methadone treatment. Of those targeted for the 12-month follow-up, 4,229 were eligible (88.4% of those targeted), 3,147 were located (74.4% of those eligible), and 2,966 were successfully interviewed (70.1% of those eligible) (35,36). One participant was not included in the present 12-month follow-up sample due to missing pre-treatment sleep data. A comparison of participants who completed only the pre-treatment intake interview and those that also completed 12-month follow-up interviews indicated that these samples have similar characteristics and are generally comparable (36). Participation in the DATOS study was voluntary, and individuals provided verbal and written informed consent (36).

Measures

Substance use (outcomes)—Primary substance use problem was determined from the pre-treatment substance use assessment, and was recoded by DATOS data managers. Primary substance use problem included alcohol (n=1,057), cocaine (n=4,494), or heroin (n=1,617) use. Substance use frequency was determined from the pre-treatment substance use assessment, and was recoded by DATOS data managers. Responses included “no use,” “less than once/week,” “1–3 times/month,” “1–2 times/week,” “3–4 times/week,” “5–6 times/week,” “daily or almost every day,” “2–3 times/day,” and “4+ times/day.” Post-treatment substance use was determined from a positive response to the question, “During the past 12 months, have you used (substance)?” assessed at the 12-month post-treatment follow-up. Post-treatment substance use was restricted to alcohol, cocaine, and heroin use.

Sleep disturbance (predictors)—A lifetime history of sleep disturbance symptoms was assessed at pre-treatment. Sleep disturbance symptoms were not assessed 12-months post-treatment. A lifetime history of insomnia symptoms was determined by a positive response to any of the following questions, “Have you ever had 2 weeks or more when nearly every night you had trouble falling asleep?”, “Have you ever had 2 weeks or more when nearly every night you had trouble staying asleep?”, or “Have you ever had 2 weeks or more when nearly every night you had trouble waking up too early?”. These questions reflect difficulties with sleep onset latency (SOL), waking after sleep onset (WASO), and early morning awakening (EMA), which are core components of the diagnostic criteria for insomnia (15). A lifetime history of hypersomnia symptoms was determined by a positive response to “Have you ever had 2 weeks or longer when nearly every day you were sleeping too much?”. A negative response to any of these insomnia or hypersomnia questions was categorized as no lifetime history of sleep disturbance symptoms. Lifetime history of sleep disturbance was coded as only insomnia symptoms (n=1,885), only hypersomnia symptoms (n=680), both hypersomnia and insomnia symptoms (n=2,008), or no sleep disturbance symptoms (n=2,595). No sleep disturbance symptoms was the reference category for all analyses.

Covariates—A lifetime history of depression symptoms was determined by participant responses to, “In your lifetime, have you had at least 2 weeks during which you felt very

sad, blue, depressed, or you lost interest and pleasure in things you usually cared about or enjoyed?” Previous studies indicate that depression is associated with substance use (37–40) and sleep disturbance (41–43). Substance use during treatment was assessed at the 12-month post-treatment interview with the following question, “While you were in treatment, (on the average) how often did you use (substance)?”. Participants received treatment in four modalities: short-term inpatient treatment (n=2,425), long term residential treatment (n=2,123), outpatient drug-free treatment (n=1,426), or methadone maintenance treatment (n=1,194). Age, sex, race, age, education level, and depression history were measured at the pre-treatment assessment. Demographic characteristics by sleep disturbance type are displayed in Table 1.

Data analysis

The aims of the study were tested with logistic and linear regression. The first aim was tested with binomial logistic regression with the *logit* command in STATA 14.1 (44). The independent variable (IV) was pre-treatment sleep disturbance group (0=no sleep disturbance, 1=insomnia symptoms, 2= hypersomnia symptoms, 3=both insomnia and hypersomnia symptoms) and the dependent variable (DV) was primary substance use problem at pre-treatment. Given that the primary substance use problem variable does not have a natural reference group for comparisons (e.g., “no substance use”), the variable was coded as follows: 0=cocaine, 1=alcohol; 0=cocaine, 1=heroin; or 0=heroin, 1=alcohol. The second aim was tested with linear regression with the *regress* command from STATA 14.1 (44). The IV was pre-treatment sleep disturbance group and the DV was pre-treatment substance use frequency. The third aim was tested with a binomial logistic regression with the *logit* command from STATA 14.1 (44). The IV was pre-treatment sleep disturbance group and the DV was substance use 12-months post-treatment (0=absence, 1=presence) for alcohol, cocaine, and heroin. All models also included age, sex, race, age, education level, and depression history assessed at pre-treatment as covariates. Analyses for the third aim also included treatment modality and in-treatment substance use as covariates.

Results

Lifetime history of sleep disturbance and primary substance use problem at pre-treatment

Descriptive statistics for pre-treatment sleep disturbance and substance use variables are presented in Table 1. A lifetime history of insomnia symptoms compared to no sleep disturbance symptoms was significantly related to a higher likelihood of reporting alcohol use compared to cocaine use and a higher likelihood of reporting heroin use compared to cocaine use (Table 2). A lifetime history of hypersomnia symptoms compared to no sleep disturbance symptoms was significantly related to a higher likelihood of reporting cocaine use and alcohol use compared to heroin use (Table 2). A lifetime history of reporting both insomnia and hypersomnia symptoms compared to no sleep disturbance symptoms was not significantly related to a higher likelihood of reporting a particular substance (Table 2).

Lifetime history of sleep disturbance and substance use frequency at pre-treatment

A lifetime history of insomnia symptoms as well as reporting a lifetime history of both insomnia and hypersomnia compared to no sleep disturbance symptoms were significantly

related to greater substance use frequency (Table 2). A lifetime history of hypersomnia symptoms was not significantly related substance use frequency (Table 2).

Pre-treatment sleep disturbance and substance use 12-months post-treatment

Alcohol, cocaine, and heroin use 12-months post-treatment for each sleep disturbance group are reported in Table 1. Compared to no sleep disturbance symptoms, participants that reported a lifetime history of insomnia symptoms at pre-treatment had a 30% increase in the odds of reporting cocaine use 12-months post-treatment (Table 3). In addition, individuals that reported a lifetime history of hypersomnia symptoms at pre-treatment compared to no sleep disturbance symptoms had a 52% increase in the odds of reporting cocaine use 12-months post-treatment (Table 3). Participants that reported a lifetime history of both insomnia and hypersomnia symptoms at pre-treatment also had a 57% increase in the odds of reporting cocaine use 12-months post-treatment (Table 3). In contrast, all three types of sleep disturbance assessed at pre-treatment (insomnia, hypersomnia, or both insomnia and hypersomnia) were not significantly related to alcohol or heroin use 12-months post-treatment (Table 3).

Discussion

The present study tested hypotheses about the effect of a lifetime history of insomnia symptoms, hypersomnia symptoms, or both insomnia and hypersomnia symptoms compared to no sleep disturbance on alcohol, cocaine, and heroin use patterns, substance use frequency, and substance use 12-months post-treatment in a large-scale sample of adults seeking substance use treatment in the United States. A lifetime history of insomnia symptoms was associated with a greater likelihood of reporting alcohol and heroin use compared to cocaine use. These findings are consistent with other research that has shown that insomnia is related to alcohol and heroin use (3,10,18,19,24). This is also one of the first studies to indicate that insomnia symptoms may be more strongly related to alcohol and heroin use than cocaine use for adults seeking community-based substance use treatment in the United States. A lifetime history of hypersomnia symptoms was related to a greater likelihood of reporting cocaine and alcohol than heroin use. One possibility is that cocaine may be used to self-medicate hypersomnia symptoms; however, it may also be the case that cocaine withdrawal results in hypersomnia symptoms, which are then self-medicated with alcohol (22). This study adds to a growing literature on hypersomnia and substance use that has been previously limited by low rates of substance use (45). The current study did not find evidence that reporting both a lifetime history of insomnia and hypersomnia symptoms was related to a particular substance use pattern. Differentiating types of sleep disturbance such as insomnia and hypersomnia may be an important consideration in determining an individual's primary substance use problem.

Compared to no sleep disturbance symptoms, individuals that reported a lifetime history of insomnia symptoms as well as both a lifetime history of insomnia and hypersomnia used substances more frequently. One explanation for these findings is that individuals who report insomnia symptoms may use substances to self-medicate the daytime impairment associated with insomnia (46,47). Alternatively, substance use and withdrawal are associated with

insomnia symptoms (15), and it may be that the present findings reflect an increase in insomnia symptoms in combination with increased substance use. In contrast, a lifetime history of hypersomnia symptoms compared to no sleep disturbance symptoms was not related to substance use frequency. One possibility is that insomnia symptoms are a more salient sleep disturbance symptom given that the acute stages of substance use and withdrawal are connected with insomnia (19,21,22,48). Additionally, reporting both a lifetime history of insomnia and hypersomnia was related to higher substance use frequency, and may suggest that more sleep disturbance is associated with more frequent substance use.

A lifetime history of insomnia symptoms and hypersomnia symptoms may also be risk factors for cocaine relapse. Insomnia symptoms, hypersomnia symptoms, and both insomnia and hypersomnia symptoms were related to a higher likelihood of using cocaine 12-months post-treatment. These results add to a growing literature linking sleep and cocaine abstinence (31,49). The present study builds on these prior findings by providing evidence that a lifetime history of insomnia and hypersomnia symptoms are prospectively associated with post-treatment cocaine use in the context of a large, multisite community-based substance treatment study. One explanation for these findings is that substance use after treatment may be an attempt at alleviating withdrawal symptoms such as insomnia and hypersomnia (15,48,50). Indeed, there is evidence that sleep does not return to normal after substance use abstinence (10,48,51,52). Future research will be necessary to confirm the potential importance of a lifetime history of insomnia and hypersomnia symptoms on cocaine relapse, as well as identify the mechanisms involved in this relationship. Neither a lifetime history of insomnia nor hypersomnia symptoms reported at pre-treatment significantly predicted heroin or alcohol use 12-months post-treatment. Regarding heroin, the lack of an effect may be due to the relatively lower rate of post-treatment heroin use (17.4%). The absence of an effect for post-treatment alcohol use is surprising given prior evidence for this relationship (10), and further highlights the need for prospective studies with validated measures of sleep disturbance.

Although the findings from the present study provide further evidence for the relationship between sleep disturbance and substance use and relapse, there are limitations to this study. First, this study was cross-sectional and utilized retrospective self-reported sleep disturbance and substance use. Hence, it is not possible to determine if sleep disturbance causes substance use, if substance use causes sleep disturbance, or if other variables may account for these relationships. Experimental and prospective studies are needed to investigate sleep disturbance symptoms and substance use in order to determine the directionality of these results. Objective measures of sleep disturbance and substance use should also be a priority in future research. Second, the present study utilized data collected between 1991 and 1994, which may limit the generalizability of these effects to the current era. However, it is notable that evidence for a linkage between sleep disturbance and substance use has continued to emerge over time (53,54). Third, a substantial number of pre-treatment participants were not included in the 12-month post-treatment assessment. Although missing data is common in longitudinal substance use treatment studies (55), findings from the 12-month follow-up sample should be interpreted with caution as they may not be representative of the pre-treatment sample. Fourth, this study did not evaluate insomnia or hypersomnia diagnosis, but rather used questions that target a lifetime history of insomnia and hypersomnia symptoms.

Hence, it is not possible to determine the temporal relationship between sleep disturbance and substance use. Further, the endorsement of sleeping too much may also reflect extended time in bed rather than hypersomnia (56,57). While these questions do reflect the core diagnostic criteria for insomnia as well as one core symptom of hypersomnia (15), future studies will benefit from implementing a prospective design with validated measures of insomnia and hypersomnia symptoms or a diagnostic interview that evaluates insomnia and hypersomnia diagnosis. Finally, the DATOS study included 96 treatment sites. However, treatment site identifiers were not included in the DATOS dataset due to confidentiality risks (58). As such, the findings from this study should be interpreted with caution as *p*-values and confidence intervals may be inaccurately estimated without accounting for site-level clustering.

In conclusion, these findings provide additional support for an association between substance use and sleep disturbance. Specifically, the study showed that lifetime history of insomnia and hypersomnia was associated with higher frequency of all substance use at treatment entry and higher rates of cocaine use at the 12-month post-treatment assessment among adults entering substance use treatment in the United States. Given the potential importance of this association, future research should use prospective designs to determine if screening for sleep disturbance can inform substance use treatment and relapse prevention efforts. Additionally, research may also benefit from examining treatments that target sleep disturbance in the context of substance use, particularly given evidence that sleep medications can improve sleep disturbance associated with marijuana withdrawal (59).

Acknowledgments

This research was supported by the National Institute of Mental Health grants R01MH105513 and T32MH020006.

References

1. Bootzin RR, Stevens SJ. Adolescents, substance abuse, and the treatment of insomnia and daytime sleepiness. *Clin Psychol Rev* [Internet]. 2005; 25(5):629–44. [cited 2014 Jan 21]. Available from: <http://www.sciencedirect.com/science/article/pii/S0272735805000334>.
2. Johnson EO, Breslau N. Sleep problems and substance use in adolescence. *Drug Alcohol Depend* [Internet]. 2001 Sep; 64(1):1–7. [cited 2014 Feb 14]. Available from: <http://www.sciencedirect.com/science/article/pii/S0376871600002222>.
3. Liao Y, Tang J, Liu T, Chen X, Luo T, Hao W. Sleeping problems among Chinese heroin-dependent individuals. *Am J Drug Alcohol Abuse* [Internet]. 2011 May; 37(3):179–83. [cited 2016 Apr 22]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/21438798>.
4. Gillin JC. Are sleep disturbances risk factors for anxiety, depressive and addictive disorders? *Acta Psychiatr Scand* [Internet]. 1998 Dec; 98(s393):39–43. [cited 2016 Apr 24]. Available from: <http://doi.wiley.com/10.1111/j.1600-0447.1998.tb05965.x>.
5. Roehrs T, Roth T. Sleep Disturbance in Substance Use Disorders. *Psychiatr Clin North Am* [Internet]. 2015 Dec; 38(4):793–803. [cited 2016 Apr 24]. Available from: <http://www.sciencedirect.com/science/article/pii/S0193953X15000830>.
6. Schierenbeck T, Riemann D, Berger M, Hornyak M. Effect of illicit recreational drugs upon sleep: cocaine, ecstasy and marijuana. *Sleep Med Rev* [Internet]. 2008 Oct; 12(5):381–9. [cited 2016 Apr 21]. Available from: <http://www.sciencedirect.com/science/article/pii/S1087079207001670>.
7. Garcia AN, Salloum IM. Polysomnographic sleep disturbances in nicotine, caffeine, alcohol, cocaine, opioid, and cannabis use: A focused review. *Am J Addict* [Internet]. 2015 Oct; 24(7):590–8. [cited 2016 Apr 13]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/26346395>.

8. Angarita GA, Emadi N, Hodges S, Morgan PT. Sleep abnormalities associated with alcohol, cannabis, cocaine, and opiate use: a comprehensive review. *Addict Sci Clin Pract* [Internet]. 2016; 11(1):9. [cited 2016 Jun 25]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/27117064>.
9. Julien, R., Advocat, C., Comaty, J. A primer of drug action. 122011. Internet A series of books in psychology Available from: <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=psyc3&AN=1988-97817-000%5Cnhttp://sfx.scholarsportal.info/mcmaster?sid=OVID:psycdb&id=pmid:&id=doi:&issn=&isbn=0716719622&volume=&issue=&spage=&pages=&date=1988&title=A+primer+of+drug+acti>
10. Brower KJ, Aldrich MS, Robinson EA, Zucker RA, Greden JF. Insomnia, self-medication, and relapse to alcoholism. *Am J Psychiatry* [Internet]. 2001 Mar; 158(3):399–404. [cited 2016 Apr 21]. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3008542&tool=pmcentrez&rendertype=abstract>.
11. Roehrs T, Hollebeek E, Drake C, Roth T. Substance use for insomnia in Metropolitan Detroit. *J Psychosom Res* [Internet]. 2002 Jul; 53(1):571–6. [cited 2016 Apr 24]. Available from: <http://www.sciencedirect.com/science/article/pii/S0022399902004488>.
12. Kaneita Y, Uchiyama M, Takemura S, Yokoyama E, Miyake T, Harano S, et al. Use of alcohol and hypnotic medication as aids to sleep among the Japanese general population. *Sleep Med* [Internet]. 2007 Nov; 8(7–8):723–32. [cited 2016 Apr 24]. Available from: <http://www.sciencedirect.com/science/article/pii/S1389945706006411>.
13. Ancoli-Israel S, Roth T. Characteristics of insomnia in the United States: results of the 1991 National Sleep Foundation Survey. I. *Sleep* [Internet]. 1999 May 1; 22(Suppl 2):S347–53. [cited 2014 Feb 19]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/10394606>.
14. Ohayon MM. Epidemiology of insomnia: what we know and what we still need to learn. *Sleep Med Rev* [Internet]. 2002 Apr; 6(2):97–111. [cited 2014 Feb 12]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/12531146>.
15. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5. Arlington, VA: American Psychiatric Publishing, Inc; 2013. Diagnostic and statistical manual of mental disorders; p. 991
16. Breslau N, Roth T, Rosenthal L, Andreski P. Sleep disturbance and psychiatric disorders: A longitudinal epidemiological study of young Adults. *Biol Psychiatry* [Internet]. 1996 Mar; 39(6): 411–8. [cited 2016 Feb 28]. Available from: <http://www.sciencedirect.com/science/article/pii/S0006322395001883>.
17. Ford DE, Kamerow DB. Epidemiologic Study of Sleep Disturbances and Psychiatric Disorders. *JAMA* [Internet]. 1989 Sep 15; 262(11):1479. [cited 2014 Jan 22]. Available from: <http://jama.jamanetwork.com/article.aspx?articleid=378663>.
18. Roehrs T, Papineau K, Rosenthal L, Roth T. Ethanol as a hypnotic in insomniacs: self administration and effects on sleep and mood. *Neuropsychopharmacology* [Internet]. 1999 Mar; 20(3):279–86. [cited 2016 Apr 9]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/10063488>.
19. Brower KJ. Insomnia, alcoholism and relapse. *Sleep Med Rev* [Internet]. 2003 Dec; 7(6):523–39. [cited 2016 Apr 22]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15018094>.
20. Brower KJ. Assessing and Treating Insomnia Related to Alcohol Use Disorders. *Curr Addict Reports* [Internet]. 2016 Mar 18; 3(1):98–108. [cited 2016 Nov 6]. Available from: <http://link.springer.com/10.1007/s40429-016-0083-1>.
21. Johanson CE, Roehrs T, Schuh K, Warbasse L. The effects of cocaine on mood and sleep in cocaine-dependent males. *Exp Clin Psychopharmacol* [Internet]. 1999 Nov; 7(4):338–46. [cited 2016 Apr 22]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/10609968>.
22. Gawin FH. Abstinence Symptomatology and Psychiatric Diagnosis in Cocaine Abusers. *Arch Gen Psychiatry* [Internet]. 1986 Feb 1; 43(2):107. [cited 2016 Apr 24]. Available from: <http://archpsyc.jamanetwork.com/article.aspx?articleid=493732>.
23. Kay DC, Pickworth WB, Neidert GL, Falcone D, Fishman PM, Othmer E. Opioid effects on computer-derived sleep and EEG parameters in nondependent human addicts. *Sleep* [Internet]. 1979; 2(2):175–91. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/232563>.

24. Kay D, Pickworth W, Neider G. Morphine-like insomnia from heroin in nondependent human addicts. *Br J Clin Pharmacol*. 1981; 11(2):159–69. [PubMed: 7213520]
25. Wang D, Teichtahl H. Opioids, sleep architecture and sleep-disordered breathing. *Sleep Medicine Reviews*. 2007:35–46. [PubMed: 17141540]
26. Howe RC, Hegge FW, Phillips JL. Acute heroin abstinence in man: I. Changes in behavior and sleep. *Drug Alcohol Depend*. 1980; 5(5):341–56. [PubMed: 7371499]
27. Lewis SA, Oswald I, Evans JI, Akindele MO, Tompsett SL. Heroin and human sleep. *Electroencephalogr Clin Neurophysiol*. 1970; 28(4):374–81. [PubMed: 4191189]
28. Brower KJ, Perron BE. Sleep disturbance as a universal risk factor for relapse in addictions to psychoactive substances. *Med Hypotheses* [Internet]. 2010 May; 74(5):928–33. [cited 2014 Apr 23]. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2850945&tool=pmcentrez&rendertype=abstract>.
29. Drummond SP, Gillin JC, Smith TL, DeModena A. The sleep of abstinent pure primary alcoholic patients: natural course and relationship to relapse. *Alcohol Clin Exp Res* [Internet]. 1998 Nov; 22(8):1796–802. [cited 2016 Apr 24]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/9835298>.
30. Brower KJ, Aldrich MS, Hall JM. Polysomnographic and Subjective Sleep Predictors of Alcoholic Relapse. *Alcohol Clin Exp Res* [Internet]. 1998 Nov; 22(8):1864–71. [cited 2014 Apr 23]. Available from: <http://doi.wiley.com/10.1111/j.1530-0277.1998.tb03995.x>.
31. Morgan PT, Angarita GA, Canavan S, Pittman B, Oberleitner L, Malison RT, et al. Modafinil and sleep architecture in an inpatient–outpatient treatment study of cocaine dependence. *Drug Alcohol Depend*. 2016; 160:49–56. [PubMed: 26777774]
32. Chen B, Wang Y, Liu X, Liu Z, Dong Y, Huang YH. Sleep Regulates Incubation of Cocaine Craving. *J Neurosci* [Internet]. 2015 Sep 30; 35(39):13300–10. [cited 2016 May 22]. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4588606&tool=pmcentrez&rendertype=abstract>.
33. Dijkstra BAG, De Jong CAJ, Krabbe PFM, van der Staak CPF. Prediction of Abstinence in Opioid-Dependent Patients. *J Addict Med* [Internet]. 2008 Dec; 2(4):194–201. [cited 2016 Nov 3]. Available from: <http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=01271255-200812000-00004>.
34. Lydon-Staley DM, Cleveland HH, Huhn AS, Cleveland MJ, Harris J, Stankoski D, et al. Daily sleep quality affects drug craving, partially through indirect associations with positive affect, in patients in treatment for nonmedical use of prescription drugs. *Addict Behav*. 2017; 65:275–82. [PubMed: 27544697]
35. Flynn PM, Craddock SG, Hubbard RL, Anderson J, Etheridge RM. Methodological overview and Research Design for the Drug Abuse Treatment Outcome Study (DATOS). *Psychol Addict Behav*. 1997; 11(4):230–43.
36. Hubbard RL, Craddock SG, Flynn PM, Anderson J, Etheridge RM. Overview of 1-year follow-up outcomes in the Drug Abuse Treatment Outcome Study (DATOS). *Psychol Addict Behav*. 1997; 11(4):261–78.
37. Davis L, Uezato A, Newell JM, Frazier E. Major depression and comorbid substance use disorders. *Curr Opin Psychiatry* [Internet]. 2008 Jan; 21(1):14–8. [cited 2016 Apr 4]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/18281835>.
38. Currie SR, Patten SB, Williams JVA, Wang J, Beck CA, El-Guebaly N, et al. Comorbidity of major depression with substance use disorders. *Can J Psychiatry* [Internet]. 2005 Sep; 50(10):660–6. [cited 2016 Apr 11]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16276858>.
39. Dodge R, Sindelar J, Sinha R. The role of depression symptoms in predicting drug abstinence in outpatient substance abuse treatment. *J Subst Abuse Treat* [Internet]. 2005 Mar; 28(2):189–96. [cited 2016 Apr 16]. Available from: <http://www.sciencedirect.com/science/article/pii/S074054720400159X>.
40. Swendsen J. The comorbidity of depression and substance use disorders. *Clin Psychol Rev* [Internet]. 2000 Mar; 20(2):173–89. [cited 2016 Apr 16]. Available from: <http://www.sciencedirect.com/science/article/pii/S0272735899000264>.

41. Riemann D, Berger M, Voderholzer U. Sleep and depression — results from psychobiological studies: an overview. *Biol Psychol* [Internet]. 2001 Aug; 57(1–3):67–103. [cited 2015 Mar 5]. Available from: <http://www.sciencedirect.com/science/article/pii/S0301051101000904>.
42. Riemann D, Voderholzer U. Primary insomnia: a risk factor to develop depression? *J Affect Disord* [Internet]. 2003 Sep; 76(1–3):255–9. [cited 2014 May 18]. Available from: <http://www.sciencedirect.com/science/article/pii/S0165032702000721>.
43. Sabo E, Reynolds CF, Kupfer DJ, Berman SR. Sleep, depression, and suicide. *Psychiatry Res* [Internet]. 1991 Mar; 36(3):265–77. [cited 2015 Jan 15]. Available from: <http://www.sciencedirect.com/science/article/pii/016517819190025K>.
44. StataCorp. *Stata Statistical Software: Release 14*. 2015; 2015
45. Barateau L, Jaussent I, Lopez R, Boutrel B, Leu-Semenescu S, Arnulf I, et al. Smoking, Alcohol, Drug Use, Abuse and Dependence in Narcolepsy and Idiopathic Hypersomnia: A Case-Control Study. *Sleep* [Internet]. 2016 Mar 1; 39(3):573–80. [cited 2016 Nov 6]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/26564129>.
46. Riedel BW, Lichstein KL. Insomnia and daytime functioning. *Sleep Med Rev* [Internet]. 2000 Jun; 4(3):277–98. [cited 2016 May 20]. Available from: <http://www.sciencedirect.com/science/article/pii/S1087079299900746>.
47. Schneider C, Fulda S, Schulz H. Daytime variation in performance and tiredness/sleepiness ratings in patients with insomnia, narcolepsy, sleep apnea and normal controls. *J Sleep Res* [Internet]. 2004 Dec; 13(4):373–83. [cited 2016 May 20]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15560772>.
48. Thompson PM, Gillin JC, Golshan S, Irwin M. Polygraphic sleep measures differentiate alcoholics and stimulant abusers during short-term abstinence. *Biol Psychiatry* [Internet]. 1995 Dec 15; 38(12):831–6. [cited 2016 Apr 22]. Available from: <http://www.sciencedirect.com/science/article/pii/0006322395000704>.
49. Angarita GA, Canavan SV, Forselius E, Bessette A, Morgan PT. Correlates of polysomnographic sleep changes in cocaine dependence: self-administration and clinical outcomes. *Drug Alcohol Depend* [Internet]. 2014 Oct 1; 143:173–80. [cited 2016 Apr 28]. Available from: <http://www.sciencedirect.com/science/article/pii/S0376871614009971>.
50. Watson R, Hartmann E, Schildkraut JJ. Amphetamine withdrawal: affective state, sleep patterns, and MHPG excretion. *Am J Psychiatry* [Internet]. 1972 Sep; 129(3):263–9. [cited 2016 Apr 24]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/4340897>.
51. Cohen-Zion M, Drummond SPA, Padula CB, Winward J, Kanady J, Medina KL, et al. Sleep architecture in adolescent marijuana and alcohol users during acute and extended abstinence [Internet]. *Addictive Behaviors*. 2009; 34 [cited 2014 Jan 28]. Available from: <http://www.sciencedirect.com/science/article/pii/S0306460309001361>.
52. Matuskey D, Pittman B, Forselius E, Malison RT, Morgan PT. A multistudy analysis of the effects of early cocaine abstinence on sleep. *Drug Alcohol Depend* [Internet]. 2011 May 1; 115(1–2):62–6. [cited 2016 May 22]. Available from: <http://www.sciencedirect.com/science/article/pii/S0376871610003704>.
53. Hasler BP, Smith LJ, Cousins JC, Bootzin RR. Circadian rhythms, sleep, and substance abuse. *Sleep Med Rev* [Internet]. 2012; 16(1):67–81. [cited 2014 Jan 22]. Available from: <http://www.sciencedirect.com/science/article/pii/S1087079211000335>.
54. Conroy DA, Arnedt JT. Sleep and substance use disorders: an update. *Curr Psychiatry Rep* [Internet]. 2014 Oct. 16(10):487. [cited 2016 Nov 6]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/25135784>.
55. McPherson S, Barbosa-Leiker C, Burns GL, Howell D, Roll J. Missing data in substance abuse treatment research: current methods and modern approaches. *Exp Clin Psychopharmacol* [Internet]. 2012 Jun; 20(3):243–50. [cited 2016 May 13]. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3785093&tool=pmcentrez&rendertype=abstract>.
56. Kaplan KA, Harvey AG. Hypersomnia across mood disorders: A review and synthesis. *Sleep Med Rev*. 2009; 13(4):275–85. [PubMed: 19269201]

57. Kaplan KA, Gruber J, Eidelman P, Talbot LS, Harvey AG. Hypersomnia in inter-episode bipolar disorder: does it have prognostic significance? *J Affect Disord* [Internet]. 2011 Aug; 132(3):438–44. [cited 2016 Nov 10]; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/21489637>.
58. Inter-university Consortium for Political and Social Research. ICPSR/SAMHDA Data Cleaning and Processing: Codebook for Intake 1 Data, Drug Abuse Treatment Outcome Study (DATOS), 1991–1994. Ann Arbor: 2012. p. 9
59. Vandrey R, Smith MT, McCann UD, Budney AJ, Curran EM. Sleep disturbance and the effects of extended-release zolpidem during cannabis withdrawal. *Drug Alcohol Depend*. 2011; 117(1):38–44. [PubMed: 21296508]

Table 1
 Descriptive characteristics of sleep, substance use, and demographic variables by sleep disturbance type assessed at pre-treatment and substance use at 12-months post-treatment

Characteristic	Insomnia symptoms		Hypersomnia symptoms		Both insomnia and hypersomnia symptoms		No sleep disturbance	
	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %
Pre-treatment sleep disturbance	1885	26.3%	680	9.5%	2008	28.0%	2595	36.2%
12-month sleep disturbance	784	26.4%	289	9.7%	784	26.4%	1108	37.4%
Age	34.0	7.3	30.7	6.8	32.1	7.0	32.9	7.2
Gender (n=female)	623	33.1%	248	36.5%	825	41.1%	755	29.1%
Race								
African-American	944	50.1%	331	48.7%	890	44.3%	1,485	57.2%
Caucasian	682	36.2%	255	37.5%	831	41.4%	744	28.7%
Hispanic	213	11.3%	79	11.6%	239	11.9%	300	11.6%
Other	46	2.4%	15	2.2%	48	2.4%	66	2.5%
Education Level								
Grade school	92	4.9%	21	3.1%	105	5.2%	95	3.7%
High school	583	30.9%	206	30.3%	661	32.9%	824	31.8%
High school degree	733	38.9%	270	39.7%	750	37.4%	994	38.3%
Some college	317	16.8%	132	19.4%	329	16.4%	464	17.9%
Associate's degree	81	4.3%	21	3.1%	79	3.9%	109	4.2%
Bachelor's degree	65	3.5%	22	3.2%	77	3.8%	95	3.7%
Advanced degree	13	0.7%	8	1.2%	7	0.3%	14	0.5%
Depression history	1,057	56.3%	273	40.3%	1,437	72.0%	565	21.8%
Substance use type								
Alcohol	310	16.4%	102	15.0%	313	15.6%	332	12.8%
Cocaine	1,069	56.7%	475	69.9%	1,271	63.3%	1,679	64.7%
Heroin	506	26.8%	103	15.1%	424	21.1%	584	22.5%
Substance use frequency ^a	5.3	2.3	4.9	2.2	5.3	2.2	4.8	2.3
Substance use during treatment assessed at 12-month follow-up ^b								
Alcohol (use/no use)	160/595	21.2%	46/234	16.4%	149/606	19.7%	206/849	19.5%
Cocaine (use/no use)	139/614	18.5%	44/234	15.8%	134/617	17.8%	182/869	17.3%

Characteristic	Insomnia symptoms		Hypersomnia symptoms		Both insomnia and hypersomnia symptoms		No sleep disturbance	
	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %
Heroin (use/no use)	120/633	17.3%	29/251	10.4%	98/654	13.0%	143/910	13.6%
Substance use in past 12-months assessed at 12-month follow-up ^b								
Alcohol (use/no use)	438/346	55.9%	160/129	55.4%	442/342	56.4%	595/512	53.7%
Cocaine (use/no use)	301/479	38.6%	118/170	41.0%	331/453	42.2%	362/744	32.7%
Heroin (use/no use)	157/623	20.1%	41/247	14.2%	122/661	15.6%	195/911	17.6%

^a 4 = 3–4 times/week, 5 = 5–6 times/week, 6 = daily or almost every day;

^b Percentages correspond to number of cases reporting use divided by total number of cases by sleep disturbance type.

Comparison of substance use and substance use frequency for participants with a lifetime history of insomnia, hypersomnia symptoms, or both insomnia and hypersomnia symptoms compared to no sleep disturbance symptoms assessed at pre-treatment.

Table 2

	β	SE	z/t	p	OR	95% C.I.
Insomnia symptoms						
Alcohol (reference: cocaine)	0.315	0.096	3.270	.001	1.37	[1.13, 1.66]
Heroin (reference: cocaine)	0.282	0.082	3.430	.001	1.33	[1.13, 1.56]
Alcohol (reference: heroin)	0.059	0.107	0.560	.579	1.06	[0.86, 1.31]
Substance use frequency	0.424	0.071	5.940	<.001	-	[0.28, 0.56]
Hypersomnia symptoms						
Alcohol (reference: cocaine)	0.068	0.130	0.530	.599	1.07	[0.83, 1.38]
Cocaine (Reference: heroin)	0.370	0.128	2.900	.004	1.45	[1.13, 1.86]
Alcohol (reference: heroin)	0.369	0.162	2.270	.023	1.45	[1.05, 1.99]
Substance use frequency	0.050	0.098	0.510	.609	-	[-0.14, 0.24]
Insomnia and hypersomnia symptoms						
Alcohol (reference: cocaine)	0.117	0.099	1.180	.238	1.12	[0.93, 1.37]
Heroin (reference: cocaine)	-0.007	0.088	-0.080	.934	0.99	[0.84, 1.18]
Alcohol (reference: heroin)	0.096	0.113	0.850	.398	1.10	[0.88, 1.37]
Substance use frequency	0.508	0.074	6.900	<.001	-	[0.36, 0.65]

Dependent variables: alcohol use, cocaine use, heroin use, or substance use frequency assessed at pre-treatment. Independent variables: a lifetime history of insomnia, hypersomnia symptoms, or both insomnia and hypersomnia symptoms compared to no sleep disturbance symptoms assessed at pre-treatment. Covariates: age, sex, race, education level, and depression history assessed at pre-treatment.

Table 3

Alcohol, cocaine, and heroin use at 12-months post-treatment predicted by lifetime history of insomnia or hypersomnia symptoms compared to no sleep disturbance reported at pre-treatment.

	β	SE	z	p	OR	95% C.I.
Insomnia symptoms						
Alcohol	0.104	0.107	0.970	.330	1.11	[0.90, 1.37]
Cocaine	0.260	0.112	2.330	.020	1.30	[1.04, 1.62]
Heroin	0.024	0.167	0.140	.886	1.02	[0.74, 1.42]
Hypersomnia symptoms						
Alcohol	0.099	0.145	0.680	.495	1.10	[0.83, 1.47]
Cocaine	0.421	0.150	2.810	.005	1.52	[1.14, 2.04]
Heroin	-0.083	0.243	-0.340	.732	0.92	[0.57, 1.48]
Insomnia and hypersomnia symptoms						
Alcohol	0.134	0.112	1.200	.231	1.14	[0.92, 1.42]
Cocaine	0.450	0.116	3.890	<.001	1.57	[1.25, 1.97]
Heroin	-0.214	0.182	-1.170	.241	0.81	[0.57, 1.15]

Dependent variables: Alcohol, cocaine, and heroin use (presence or absence) at 12-months post-treatment. Independent variables: a lifetime history of insomnia, hypersomnia symptoms, or both insomnia and hypersomnia symptoms compared to no sleep disturbance symptoms assessed at pre-treatment. Covariates: age, sex, race, education level, depression history, treatment modality, and in-treatment substance use.