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Anhedonia and Substance Use Disorders by Type, Severity, and with Mental Health Disorders

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Abstract

Objectives: Anhedonia can accompany substance use disorders (SUDs); its severity may vary by substance type, severity of SUD symptoms, or psychiatric comorbidity. The goal of this study was to clarify the contribution of each.

Methods: Data were from participants aged 18–65 years in the National Epidemiologic Survey on Alcohol and Related Conditions III (n = 30,999; 51% women), a cross-sectional, nationally representative sample reporting lifetime DSM-5 symptoms and lifetime anhedonia. We used logistic regression to test how anhedonia was associated with specific SUDs and psychiatric disorders in respondents with one lifetime diagnosis. We used latent class analysis (LCA) to assess the association of anhedonia with patterns of comorbidity in all respondents.

Results: Opioid use disorder (OUD) had the greatest odds of anhedonia relative to other SUDs (ORs [95% CIs]): mild alcohol use disorder (AUD) (**3.33** [1.74, 6.38]), moderate/severe AUD (**2.73** [1.41, 5.30]), and cannabis use disorder (**3.21** [1.43, 7.19]), though not significantly greater than stimulant use disorder (**2.44** [.88, 6.73]). Anhedonia was more likely in mood disorders and PTSD than in any SUD, except for PTSD vs. OUD (OR [95% CIs] = **.98** [.47, 2.02]). In LCA analyses, the Poly Disorder class, which included SUDs and other diagnoses, had greater odds of anhedonia than the Poly SUD (ORs [95% CIs] = **1.62** [1.25, 2.09) and AUD (**2.89** [2.40, 3.48]) classes.

Conclusions: People with OUD or a lifetime history of mood disorder or PTSD may be most likely to present to SUD treatment with anhedonia.

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Keywords

substance use disorder treatment; opioid use disorder; anhedonia; psychiatric co-morbidity

Introduction

The experience of pleasure, which involves positively valanced emotions like enjoyment and engagement, is important for adaptive behavior. This is apparent when pleasure is absent or greatly diminished—a state or trait often referred to as *anhedonia*. The Diagnostic and Statistical Manual of Mental Disorders, 5th edition DSM-5, [1] broadly defines anhedonia as markedly diminished interest and enjoyment occurring over most days for at least a two-week period. In the National Institute of Mental Health Research Domain on Criteria, anhedonia (conceptualized as a disruption in the *positive-valence system*) is an underlying phenotype in several different DSM-defined disorders.[2, 3]

Anhedonia in people with substance use disorders (SUDs) is a particularly interesting issue. Lack of pleasure, both from drug use itself and from nondrug stimuli, has been clearly described by people with SUDs.[4] Although anhedonia is not explicitly included among the DSM-5 criteria for substance use disorders (SUDs), it may be implicit in some of them (e.g., “reduced social or recreational activities in favor of substance use”). Furthermore, influential contemporary descriptions of addiction posit that drugs “hijack” brain reward systems and make it “hard to feel pleasure from anything besides the drug”.[5] This suggests that anhedonia may be an especially important concomitant of SUDs, even if it is not an SUD symptom *per se*.

Changes in the experience of pleasure could result from a variety of factors directly or indirectly related to substance use. Investigations of anhedonia and SUDs have primarily examined the former—how anhedonia may be result from drug intake (i.e., from the neuropharmacological effects of addictive drugs). These studies have demonstrated that greater substance use severity corresponds closely with greater likelihood of anhedonia.[6–9] Anhedonia may also be a cause for, not just a consequence of, drug use. For example, people may also use drugs to enhance otherwise diminished positive moods.[10] If so, anhedonia may be especially common in people whose SUDs are comorbid with other disorders involving diminished positive moods, such as major depressive disorder (MDD) and post-traumatic stress disorder (PTSD). For MDD, anhedonia alone is sufficient to warrant diagnosis, whereas for PTSD, symptoms of anhedonia are important though neither necessary or sufficient for diagnosis.[1] MDD and PTSD are frequently comorbid with SUDs.[11, 12] Perhaps anhedonia in people with SUDs largely reflects these comorbidities. Therefore, it is important to disambiguate how anhedonia is related to SUDs alone, these other psychiatric disorders alone, and specific combinations of SUDs and other psychiatric disorders.

Properly addressing anhedonia in people with SUDs with or without other psychiatric disorders may help improve SUD treatment. Behavioral interventions often depend on a patient’s ability to engage with non-drug reinforcers, and anhedonia hinders such engagement.[13, 14] Different patients may also present to treatment with nearly identical

self-reported experiences of anhedonia, but with diverse underlying contributors (e.g., a comorbid mood disorder but less severe SUD symptoms vs. a long history of OUD but no history of psychiatric disorder). Elucidating such underlying complexities may help clinicians understand which patients are most likely to present to treatment with anhedonia and how to treat anhedonia, whether it is a primary consequence of substance use and/or associate of having an SUD *per se*, a secondary consequence from other psychiatric illness(es), and/or combinations thereof.

The Current Study

We tested the association of anhedonia with specific SUDs and DSM-5 disorders, including mood disorders, PTSD, and anxiety disorders (without history of other disorders) in a representative sample of U.S. adult survey respondents. We hypothesized that anhedonia would be strongly associated with mood disorders and PTSD, more modestly associated with SUDs (especially those other than alcohol use disorder, AUD), and only weakly associated with anxiety disorders. We chose anxiety disorders as a comparison condition because anhedonia is neither explicit nor implicit in their DSM criteria.

Next, we identified patterns of comorbidity in the respondents. We hypothesized that, among respondents with any diagnosis, the largest subgroups would be those with AUD and mood disorders. Also, we expected disorder subgroups to be highly heterogeneous, with high probabilities of multiple disorders in each disorder subgroup.

Finally, we tested the prevalence of anhedonia among respondents with different patterns of comorbidity. We hypothesized that individuals with a mood disorder or PTSD with SUDs, as well as those with multiple SUDs, would be more likely to report anhedonia compared to those with any individual disorder.

Methods

Sample

Data were drawn from the National Epidemiological Survey on Alcohol and Related Conditions III (NESARC-III), which was conducted by the National Institutes on Alcohol Abuse and Alcoholism (NIAAA). This is a nationally representative cross-sectional study of noninstitutionalized US adults (purposefully oversampling ethnic-minority respondents) that occurred from 2012 to 2013.[15–17] Overall response rate was 60%. We restricted the age range to 18–65 (n= 30,999), given the low rates of disorders at ages older than 65 years. Incorporating sample weights, the average age was 41 years old and 51% were women. Respondents were 64% White, 16% Hispanic/Latinx, 12% Black/African American, 6% Asian/Pacific Islander, and 2% American Indian/Alaska Native.

Measures

The survey instrument was the Alcohol Disorder and Associated Disabilities Interview Schedule-5 (AUDADIS-5).[15, 16] The AUDADIS-5 assessed lifetime prevalence of anhedonia with two yes/no items: “In your entire life, have you ever had a time when you didn’t care about the things that you usually cared about, or when you didn’t enjoy the things you

usually enjoyed, nearly every day for at least two weeks?" or "In your entire life, have you ever had a time when other people noticed that you no longer cared about things or enjoyed things, nearly every day for at least two weeks?" These were part of the assessment of MDD, but were asked of all participants to assess subthreshold symptoms. We coded "yes" response to either item as anhedonia.

For SUDs, the diagnostic threshold was ≥2 symptoms. Specific SUDs included cannabis use disorder (CUD), opioid use disorder (OUD, involving heroin, prescription opioids, or both), stimulant use disorder (StimUD, involving prescription stimulants or other stimulants, such as cocaine), and alcohol use disorder (AUD)[1]. The diagnostic categories we examined in addition to SUDs were mood disorders (MDD and persistent depressive disorder), PTSD, and anxiety disorders (generalized anxiety, specific phobia, agoraphobia, panic disorder, and social phobia). Participants were coded as having a disorder if they met DSM-5 criteria and if the presence of a disorder was not better explained by the symptoms of another disorder or a general medical condition.

Statistical Analysis

The analyses addressed three main objectives: (1) to test the associations between single disorders and anhedonia, (2) to identify comorbidity patterns, and (3) to test the association between comorbidity patterns and anhedonia. All analyses incorporated sample weights to maximize generalizability.

For objective 1, we used multiple logistic regression, including only respondents who had met lifetime criteria for one specific diagnosis or no diagnosis. The predictor of interest was "Disorder status" (8 levels, including "no lifetime disorder")[2]. Each level was used as the reference level in one model so all pairwise comparisons could be shown. Covariates were race, sex, age, and marital status. The association of disorder status with anhedonia was expressed as odds ratios with 95% confidence intervals. All analyses, including the determination of sample weights, were conducted using SAS version 9.4.[20]

For objective 2, we applied latent class analysis (LCA) [21, 22] to the full sample of adults aged 18–65 years. LCA is a type of finite mixture modeling that can be used when it is hypothesized that the population consists of two or more subgroups whose memberships must be inferred. We identified latent classes based on configurations of our seven diagnostic indicators, six of which were dichotomous (no disorder vs. disorder), and one of which had three levels (no AUD, AUD-Mild, and AUD-Moderate/Severe). We considered models with 2–6 latent classes. Each model was tested with 1,000 sets of random starting values; models were considered well-identified when at least 50% of the sets of random starting values converged to the same maximum-likelihood solution. To compare relative model fit we used the Akaike information criterion (AIC), [23] Bayesian information

[1]Because AUD was highly prevalent and because greater AUD severity may be more often accompanied by psychiatric comorbidity[18,19] we created a three-level indicator for severity: no AUD (0 symptoms) AUD-Mild (2–3 symptoms), and AUD-Moderate/Severe (4 or more symptoms). Additional information regarding substance use disorder prevalences by severity can be found in a prior NESARC-III publication.

[2]We excluded respondents with a lifetime bipolar I disorder, or borderline or schizotypal personality disorders, because they may confound the link between anhedonia and the disorders of interest for our main analyses.

criterion (BIC), [24] consistent AIC (CAIC), [25] and sample-size-adjusted BIC (aBIC),[26] where lower values indicate more optimal balance between model fit and model parsimony[3]. These analyses were conducted using SAS version 9.4.[20]

For objective 3, we used logistic regression to predict anhedonia from latent-class membership. To account for uncertainty of class membership, the predictor of interest was based on modal assignment with measurement-error weighting [28]; covariates indicating race, sex, age, marital status, bipolar I disorder, and borderline and personality disorders were included. Anhedonia was expressed as adjusted odds ratios with 95% confidence intervals. This analysis was conducted using Mplus version 8.[29]

Results

Descriptive Statistics

Table 1 shows the numbers of respondents who met lifetime diagnostic criteria. The least prevalent diagnoses were OUD (3%) and StimUD (4%); the most prevalent were AUD-Mild (17%), Any Anxiety Disorder (18%), and Any Mood Disorder (23%). The largest group of participants met no diagnostic criteria (47%).[4]

Associations Between Single Disorders and Lifetime Anhedonia—In the subset of respondents with no or a single disorder (22,221 out of 30,999), the unadjusted probability of endorsing lifetime history of anhedonia was greatest for respondents with lifetime history of Any Mood Disorder (.84), followed by PTSD (.25) and OUD (.25), Anxiety Disorders (.15), StimUD (.12), AUD-Moderate/Severe (.10), AUD-Mild (.08), CUD (.08), and No Disorder (.07).

Table 2 shows results from logistic regressions with each disorder used as the reference level (adjusting for race, sex, age, and marital status), enabling all possible pairwise comparisons. Compared to No Disorder, every disorder was associated with greater odds of anhedonia except for CUD and StimUD. The odds ratios were an order of magnitude larger for mood disorders than for any other category. The rank order was as follows (~ denotes no significant difference between disorders): Mood Disorder > PTSD ~ OUD > Anxiety Disorders ~ AUD-Moderate/Severe > AUD-Mild ~ StimUD ~ CUD > No Disorder.

In controlling for covariates, we found decreased odds of lifetime anhedonia for Asian/Pacific Islander respondents, and only slightly decreased odds for Hispanic/Latinx respondents, both relative to White respondents [aOR = .70, 95% CI (.56, .88); aOR = .82, 95% CI (.72, .93)]. Anhedonia did not differ significantly between White respondents and Black or American Indian/Alaska Native respondents [aOR = .90, 95% CI (.80, 1.02); aOR = 1.08, 95% CI (.72, 1.62)]. Women had greater odds of lifetime disorder relative to men [aOR = 1.28, 95% CIs (1.15, 1.41)] and odds of anhedonia increased with each year of age [aOR = 1.01, 95% CI (1.01, 1.02)]. Finally, for marital status, there was increased odds

[3]We did not use a bootstrap likelihood ratio test (BLRT) because the current LCA Bootstrap macro cannot handle multinomial indicators.[27]

[4]Among the 8,978 respondents from the full sample who endorsed one or both items on anhedonia, 81% (7,275) endorsed both, 17% (1,484) endorsed “yes” for “you noticed” only, and 2% (219) endorsed “yes” to “others noticed” only.

of anhedonia for those who were widowed/divorced/separated but not for those who were never married; these comparisons were both relative to those who were married/cohabitating with a partner [aOR = 1.31, 95% CI (1.16, 1.49); aOR = 1.13, 95% CI (.99, 1.27)].

Patterns of Comorbidity Detected by Latent Class Analysis

We compared models with 2–6 latent classes (Table 3); a 7-class model was poorly identified and not further considered. The 5-class model had the lowest BIC, CAIC, and aBIC compared to the other models. The AIC suggested modest improvement moving from the 5- to 6-class model; however, AIC is known to favor less parsimonious models compared to other criteria.[30, 31] After careful inspection of the 5- and 6-class models, we selected the 5-class model for further analysis.

Table 4 shows the overall endorsement probabilities and class-specific item-response probabilities for the 5-class model. The largest class was the No Disorder class (65%) characterized by low probability of meeting criteria for each disorder. The second largest was the AUD class (15%), characterized by a high probability of mild or moderate/severe AUD. The third largest was the Mood and Anxiety Disorders class (14%), characterized by high probabilities of those disorders and low probabilities of the other disorders. The smallest classes were Poly-Disorder (4%) and Poly-SUD (2%). The Poly-Disorder class was characterized by high probabilities of endorsing anxiety disorders, mood disorders, and PTSD, along with CUD and moderate/severe AUD. The Poly-SUD class was characterized by high probabilities of moderate/severe AUD, StimUD, OUD, and CUD, along with mood disorders.

Comorbidity Patterns (Latent-Class Memberships) as Predictors of Anhedonia

The estimated probability of endorsing anhedonia based on a model with no covariates was greatest for the Poly Disorder class (.91), followed by the Mood and Anxiety Disorder class (.88), then the Poly SUD class (.59), and the AUD class (.28). The No Disorder class had the lowest probability of endorsing anhedonia (.12).

The estimated odds of lifetime anhedonia were greater in every latent class than in the No Disorder class after adjusting for race, age, sex, marital status, bipolar I disorder, and borderline and schizotypal personality disorders (Table 5). All other pairwise comparisons were statistically significant, with the odds of anhedonia ranked as follows: Mood and Anxiety > Poly Disorder > Poly SUD > AUD > No Disorder.

Additionally, differences across levels of some of the covariates were significant. Odds of anhedonia were lower in Asian/Pacific Islander respondents [aOR = .65, 95% CI (.58, .73)], Black [aOR = .66, 95% CI (.62, .70)] respondents, and Hispanic/Latinx [aOR = .74, 95% CI (.67, .75)] respondents relative to White respondents. The difference between American Indian/Alaska Native respondents [aOR = 1.00, 95% CI (.85, 1.17)] and White respondents was not significant. Odds of anhedonia was again greater in women than in men [aOR = 1.66, 95% CIs (1.59, 1.74)] and with greater odds of anhedonia with each year of age [aOR =1.01, 95% CI (1.01, 1.01)]. For marital status, there was increased odds of anhedonia for those who were widowed/divorced/separated and for those who were never married. Both of these comparisons were relative to those who were married/cohabitating with a partner [aOR

= 1.41, 95% CI (1.33, 1.49); aOR = 1.12, 95% CI (1.06, 1.18)]. Odds of anhedonia were greater for those with bipolar I, borderline, and schizotypal disorders relative to those with no disorder [aOR = 3.21, 95% CI (2.81, 3.68); aOR =2.96, 95% CI (2.76, 3.16); aOR =1.42, 95% CI (1.29, 1.57)].

Discussion

Using a large, nationally representative sample, our study helps delineate how SUDs (both with and without comorbidities) are associated with the likelihood of anhedonia, clarifying how anhedonia is reported by people with specific SUDs, specific other psychiatric disorders, and combinations of SUD's and other psychiatric disorders. We will consider our main findings and, then, their relevance to treating SUDs.

Among specific SUD's, respondents with CUD and mild AUD were comparable in their lower likelihood of endorsing anhedonia; further, respondents with StimUD and moderate/severe AUD were similar in their intermediate likelihood of endorsing anhedonia. Although moderate/severe AUD had significantly more anhedonia than mild AUD, neither StimUD nor moderate/severe AUD differed from CUD. Overall, however, the most clear-cut finding was that respondents with OUD had the greatest likelihood of endorsing anhedonia of any SUD, with significant differences from all other SUD except StimUD. As mentioned above, the rate of anhedonia for respondents with OUD (without any comorbidities) was similar to the rate for respondents with PTSD—a disorder that includes anhedonia among its diagnostic indicators. The pronounced likelihood of anhedonia in OUD may be explained by factors directly related to opioid use, sociocultural aspects of use, and/or disorder severity. Although our current analyses cannot distinguish clearly among these possibilities, future studies on specific features that differentiate opioids and opioid use may be particularly beneficial (e.g., the prominence of physical dependence/withdrawal from opioids and opioidergic involvement in the hedonic experience, specifically, of rewards[32]). Nonpharmacological explanations for differences in anhedonia for OUD versus other substances are also relevant. Sociocultural factors may make people who use more stigmatized substances (e.g., opioids or stimulants) more likely to experience anhedonia compared to those who use other substances, like cannabis, which may be more socially acceptable itself and/or compatible with other socially accepted pleasurable activities.[33, 34]

Considering SUD "severity," our coding of AUD severity on the basis of symptom count may be a partial proxy for frequency and intensity of drinking.[35] If so, our findings are consistent with suggestions that drug exposure may dose-dependently alter reward processing, although specific dose-effect relationships for alcohol need further characterization.[36, 37] We also cannot rule out reverse or reciprocal causation. "Severity" may also be thought of in terms of the personal and societal harms associated with use that might dampen pleasurable experiences, with opioid use and cocaine use more harmful than alcohol use (especially for mild AUD) or cannabis use.[38, 39] This is consistent with the rank-order of the strengths of association with anhedonia we found across substances: OUD, StimUD, moderate/severe AUD, mild AUD = CUD.

Co-occurrence of multiple SUDs, as in our Poly SUD class, was not strongly associated with higher lifetime odds of anhedonia, especially relative to classes that included mood disorders [Mood and Anxiety], PTSD, or both [Poly Disorders]. We speculate that anhedonia in people with SUDs is typically indicative of psychiatric comorbidity or an especially severe SUD, or, for the reasons we have discussed, with OUD.

Identifying Source(s) of Anhedonia to help Treat Patients with SUDs

Interventions, such as contingency management, that rely on non-drug rewards to reinforce abstinence and other recovery-relevant behaviors are among the most effective strategies in treating SUDs.[40] However, anhedonia may reduce their effectiveness.[14] Our results offer clues for how anhedonia might be more effectively identified and addressed. Treatment planning for people with SUDs may benefit from assessment of current anhedonia in the context of patients' history of other psychiatric disorders because this information might suggest whether SUD interventions relying on non-drug rewards need to be preceded or accompanied by interventions targeted directly at anhedonia. Our rank ordering of anhedonia likelihood among SUDs might also inform how anhedonia is addressed in the light of heterogenous patient characteristics. For example, if a patient presents to SUD treatment with mild AUD, but also a history of PTSD, he or she may have anhedonia comparable to that of an OUD patient. Likewise, if a patient presents to SUD treatment with a comorbid mood disorder, anhedonia is likely a clinically relevant symptom needing to be addressed, no matter which substances the patient uses. These, among other examples from our results, may aid in such clinical considerations.

Limitations and Future Directions

In the NESARC-III data, each diagnosis, as well as the presence or absence of anhedonia, was assessed on a lifetime basis (up to the date of the interview); we could not determine the timing of anhedonia relative to each disorder. This precludes most directional or causal inference in cases where anhedonia was present. However, the *absence* of anhedonia for a given respondent *eliminates* the possibility that anhedonia could have preceded or co-occurred with a given disorder. The NESARC-III measure of anhedonia is not directly comparable to any of the longer, more detailed questionnaires typically used in research on anhedonia, but it does capture the essential feature of the absence of pleasure in a way that is appropriate for/relevant to clinical diagnosis of mental disorders. Further, for our analyses comparing disorders, multiple pairwise comparisons were conducted, thus significance levels should be interpreted with caution. The questions were also asked in a context—a structural clinical interview including questions specific to several disorders, including major depressive disorder—that could have influenced participants' responses. Nonetheless, although it is rarely investigated, a major strength of the NESARC-III is its rich data concerning mild or subthreshold DSM-5 diagnoses. Finally, the absolute and relative prevalences of different SUDs change over time, making the NESARC-III dataset an imperfect gauge or reflection of current trends. We suspect that, if we had more recent data, we might find an even stronger link between anhedonia and OUD considering the potency of opioids now more commonly used (e.g., fentanyl and its analogues). The NESARC-III dataset has the advantage of consistently using the same measure of anhedonia in a large, representative sample of the U.S. adult population, permitting head-to-head comparisons of

people with different (or no) diagnoses. Nonetheless, future epidemiological research may benefit from including more widely accepted measures of anhedonia and incorporation of such measures into longitudinal studies. This should ideally be accompanied by systematic assessment of the availability of pleasurable experiences in participants' environments.

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Table 1.

Prevalence of Lifetime Mental Health and Substance Use Disorders

Lifetime Disorders	All participants* N =30,999	Participants with history of no or only 1 disorder** N =22, 221
No Disorder	46.62%	46.62%
Substance Use Disorders		
Alcohol Use Disorder-Mild	16.95%	8.73%
Alcohol Use Disorder-Moderate/Severe	15.24%	4.21%
Cannabis Use Disorder	7.33%	0.63%
Stimulant Use Disorder	4.03%	0.21%
Opioid Use Disorder	2.60%	0.17%
Mental Health Disorders		
Any Anxiety Disorder	17.64%	3.37%
Post-traumatic Stress Disorder	6.73%	0.48%
Any Mood Disorder	23.19%	6.68%

Note. Percentages are based on estimated survey weights for the U.S. adult population ages 18–65.

* Used for latent class analyses. Disorders are *not* mutually exclusive and thus do not sum to the total.

** Used for logistic regression analyses of those with only one disorder and certain other disorders excluded from analyses.

Table 2.

Adjusted odds ratios expressing differences in odds of lifetime anhedonia when comparing two disorders

Reference Disorder	Comparison Disorder [95% CIs]							
	Alcohol Use Disorder-Mild	**Alcohol Use Disorder-Moderate/ Severe**	**Cannabis Use Disorder**	**Stimulant Use Disorder**	**Opioid Use Disorder**	**Mood Disorders**	**Post-traumatic Stress Disorder**	**Anxiety Disorder**
No Disorder	1.34*** [1.14–1.57]	1.63*** [1.33–2.00]	1.39 [.84–2.30]	1.82 [.82–4.04]	4.44*** [2.35–8.40]	70.40*** [61.48–80.61]	4.34*** [3.02–6.23]	2.22*** [1.85–2.67]
Alcohol Use Disorder- Mild	-	1.22 [.96–1.55]	1.04 [.62–1.74]	1.37 [.62–3.05]	3.33** [1.74–6.38]	52.75*** [43.72–63.64]	3.25*** [2.21–4.78]	1.66*** [1.33–2.09]
Alcohol Use Disorder- Moderate / Severe	-	-	.85 [.50–1.45]	1.12 [.50–2.53]	2.73* [1.41–5.30]	42.28*** [34.46–54.36]	2.67*** [1.78–4.01]	1.37* [1.05–1.77]
Cannabis Use Disorder	-	-	-	1.32 [.52–3.36]	3.21** 1.43–7.19]	50.82*** [30.41–84.95]	3.13*** [1.70–5.79]	1.60 [.94–2.72]
Stimulant Use Disorder	-	-	-	-	2.44 [.88–6.73]	38.64*** [17.33–86.15]	2.38 [.99–5.68]	1.22 [.54–2.74]
Opioid Use Disorder	-	-	-	-	-	15.85*** [8.31–30.23]	.98 [.47–2.02]	.50* [.26-.97]
Mood Disorder	-	-	-	-	-	-	.06*** [.04-.09]	.03*** [.03-.04]
Post-traumatic Stress Disorder	-	-	-	-	-	-	-	.51*** [.34-.75]

Note. Analyses were restricted to N=22,221 respondents with a history of only one disorder (or no disorder). All comparisons are adjusted for race, age, sex, and marital status. Alpha = .05, two-tailed.

* p <.05,

** p <.01,

*** p<.001.

Table 3.

Relative model fit information for latent class models of disorder comorbidity patterns

Number of Classes	*df*	G^2	AIC	BIC	CAIC	aBIC
2	174	2540.6	2574.6	2716.4	2733.4	2662.4
3	165	789.7	841.7	1058.6	1084.6	975.9
4	156	356.03	426.0	717.99	753.0	606.8
5	**147**	**229.4**	**317.4**	**684.4**	**728.4**	**544.56**
6	138	183.0	289.0	731.1	784.1	562.7

df = degrees of freedom, G^2 = likelihood-ratio test statistic; AIC = Akaike information criterion; BIC = Bayesian information criterion; CAIC = consistent Akaike information criterion; a-BIC = sample size adjusted BIC.

Note. Bolded text indicates the model chosen for subsequent analyses.

Table 4.

Probability of endorsing each disorder indicator, overall and for each latent class (N = 30,999)

			Disorder Latent Classes				
			No Disorders (65%) (n = 20,150)	**Alcohol Use Disorder (15%) (n = 4,650)**	**Mood and Anxiety (14%) (n = 4,340)**	**Poly Disorder (4%) (n = 1,240)**	**Poly SUD (2%) (n = 620)**
Indicators		**Overall Proportion**	**Item-Response Probabilities**				
			Substance Use Disorders				
Alcohol Use Disorder	No Disorder	.55	0.72	0.04	0.51	0.04	0.05
	Mild Disorder	.28	0.24	0.46	0.35	0.21	0.10
	Moderate/Severe Disorder	.17	0.04	0.50	0.14	0.75	0.85
Cannabis Use Disorder	No Disorder	.93	0.99	0.79	0.96	0.61	0.44
	Disorder	.07	0.01	0.21	0.04	0.39	0.56
Opioid Use Disorder	No Disorder	.98	1.00	0.97	0.99	0.88	0.67
	Disorder	.02	0.00	0.03	0.01	0.22	0.33
Stimulant Use Disorder	No Disorder	.96	1.00	0.93	0.99	0.69	0.33
	Disorder	.04	0.00	0.07	0.01	0.31	0.67
			Mental Health Disorders				
Mood Disorder	No Disorder	.77	0.91	0.72	0.34	0.42	0.58
	Disorder	.23	0.09	0.28	0.66	0.58	0.42
Anxiety Disorder	No Disorder	.83	0.95	0.84	0.42	0.23	0.80
	Disorder	.17	0.05	0.16	0.58	0.77	0.20
Post-traumatic Stress Disorder	No Disorder	.93	1.00	0.96	0.75	0.43	0.95
	Disorder	.07	0.00	0.04	0.25	0.57	0.05

Table 5.

Adjusted odds ratios expressing change in odds of lifetime anhedonia for comparison latent class relative to reference latent class.

Reference Class	Comparison Class [95% CIs]			
	Alcohol Use Disorder	**Mood and Anxiety**	**Poly Disorder**	**Poly Substance Use Disorder**
No Disorder	**1.97***** [1.73–2.12]	**8.83***** [8.02–9.74]	**5.55***** [4.70–6.54]	**3.42***** [2.91–4.03]
Alcohol Use Disorder	-	**4.60***** [4.03–5.25]	**2.89***** [2.40–3.48]	**1.79***** [1.46–2.19]
Mood and Anxiety	-	-	**.63***** [.52-.76]	**.39***** [.33-.46]
Poly Disorder	-	-	-	**.62***** [.48-.80]

Note. All comparisons are adjusted for covariates: race, age, sex, marital status, bipolar I disorder, and borderline and schizotypal personality disorders. Alpha = .05, two-tailed.

*** p<.001.