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Review article

Prevalence of substance use disorder comorbidity among individuals with eating disorders: A systematic review and meta-analysis

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ABSTRACT

Objective: : Although prior meta-analyses have significantly enriched the available literature on the comorbidity of substance use disorders (SUD) among individuals with eating disorders (ED), there have been few, recent, comprehensive reviews, and limited meta-analyses that include a range of SUDs.
Method: : In accordance with the PRISMA guidelines, six electronic databases were searched, and a total of 1013 articles were identified using a combination of search terms to identify relevant prevalence studies: eating disorder, substance-related disorder, drug dependence, drug abuse, drug addiction, substance abuse, and prevalence. After two authors screened articles and extracted data independently, 43 articles met inclusion criteria. Data was coded, and a risk of bias assessment was conducted for each included study. Meta-analysis and moderator-analysis was carried out using random-effects modelling.
Results: : The pooled lifetime and current prevalence of any comorbid SUD was 21.9% (95% CI 16.7–28.0) and 7.7% (95% CI 2.0–25.8), respectively. Tobacco (36.1 ± 23.1%), caffeine (23.8 ± 12.5%), and alcohol (20.6 ± 16.0%) were the most prevalent SUD comorbidities. Higher prevalence was observed in all-female samples, primarily Caucasian samples, and binge-purge presentations. Neither lifetime nor current prevalence were associated with age.
Discussion: : These results suggest that individuals with eating disorders should be regularly screened and offered treatment for substance use disorders concurrently during treatment for ED.

1. Introduction

Eating disorders (EDs), such as anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), are mental illnesses characterized by abnormal feeding and/or eating behaviors (American Psychiatric Association, 2013). Although EDs are generally considered to be the most lethal of all psychiatric disorders, they are relatively uncommon in the general population. According to large-scale community-based and epidemiological studies, the lifetime prevalence of AN, BN, BED, and any form of binge-eating in the general US adult population are estimated at 0.6%, 1.0%, 2.8%, and 4.5%, respectively (Hudson et al., 2007). With the exception of subthreshold BED, EDs are significantly more prevalent among women (Hudson et al., 2007). Although the general epidemiology of ED has been well studied, only a handful of studies have explored comorbidity among individuals with EDs, with the majority focusing on comorbid mood and anxiety disorders (Casper, 1998; Kaye et al., 2004). Collectively, the presence of untreated comorbid conditions is associated with poorer ED prognoses, including a greater symptom burden, a smaller likelihood of remission, and a greater degree of functional impairment (Blinder et al., 2006; Braun et al., 1994).

Comorbid substance use disorders (SUD) are also described amongst individuals with ED. Abuse of substances is common in the ED population, with up to half reporting a comorbid SUD (Bulik et al., 2004). In the National Comorbidity Study, the lifetime prevalence of comorbid SUD among adults with AN, BN, BED, subthreshold BED, or any form of binge-eating were estimated between 23–37% (Hudson et al., 2007). Comorbid alcohol use disorders (AUDs) are more frequently encountered than illicit drug use disorders (IDUD) (Hudson et al., 2007). Rates of comorbid SUD vary significantly by demographic factors (e.g., age, sex, ethnicity) and ED diagnostic subtype (Holderness et al., 1994). Furthermore, methodological factors (e.g., recruitment setting and

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assessment tools) and diagnostic factors, such as reliance on prior diagnoses or unstandardized interviews, can also influence the frequency of reported SUD comorbidity. Accordingly, a previous meta-analysis of AUDs among women with EDs identified significant variation in the size, strength, and directionality of associations between different ED patterns (e.g., binge-purge vs. restricting) and AUDs (Gadalla and Piran, 2007). Interestingly, authors have concluded that binge eating/purging behaviors specifically are associated with higher frequencies of substance use (Fouladi et al., 2015).

There are many explanations for the overlap between ED and SUD, including shared biological, psychological, and social risk factors that increase predisposition to comorbid disease development (Killeen et al., 2015). Individually, ED and SUD diagnoses share greater rates of depressive and anxiety disorders, elevated risk of suicidality, childhood adversity and trauma, shared neurochemistry of the illnesses, family history of psychiatric illness, Cluster B personality traits (particularly impulsivity), compulsive behavior, perfectionist qualities, familial and cultural influences (particularly those normalizing disordered eating and substance use), as well as emotional dysregulation (Corstorphine et al., 2007; Deep et al., 1999; Malinauskiene and Malinauskas, 2018). Overall, substance use in individuals with ED may represent a way of coping with negative emotions and intolerable affective states in the absence of adaptive coping skills (Killeen et al., 2015). Reverse associations are observed in individuals with SUD, who often binge on food as a way of coping with emotional dysregulation (Holderness et al., 1994; Spindler and Milos, 2007). Previous studies report age-of-onset priority of ED with comorbid SUD: 61.8% and 71.0% of patients with AN and BN developed ED symptoms first while close to 75% of patients with BED retrospectively reported SUD symptoms before ED onset (Hudson et al., 2007). Thus, AN and BN may have different underlying pathophysiology from BED, whose etiology could be more consistent with other impulse-control disorders (Grilo et al., 2009; Olguin et al., 2017).

From a functional and treatment perspective, SUD and ED may act synergistically, as the development of one disorder appears to be facilitated and/or sustained by the development of the other (Cochrane et al., 1998; Reba-Harrelson et al., 2009; Wolfe and Maisto, 2000). Thus, individuals treated for ED without receiving SUD treatment (or vice versa) are at high risk for symptom substitution, defined as switching from one problematic behavior to the other. Symptom switching can occur at any point during treatment but is most frequently observed during recovery. For example, during ED treatment, patients rely less on binge-purge behaviors to cope with stress but may increase dependence on substance use as a maladaptive coping skill for feelings/situations that trigger ED behaviors. Clearly, symptom substitution creates significant roadblocks in the recovery process. Treatment failure rates are high in individuals with either disorder alone, and are that much higher in those with concurrent SUD and ED. Given the interplay between ED and SUD, and the heightened risk of serious medical consequences (including death), it is important for both disorders to be identified and addressed concurrently.

Prior meta-analyses have explored SUD comorbidity among individuals with ED with the primary focus on AUDs. Consequently, there is limited information on the extent of other comorbid SUD. In the wake of the opioid epidemic and cannabis legalization, expanding the scope of meta-analyses to include other types of SUD in the ED population will enhance our understanding of the interaction between ED and SUD, and inform individualized treatment for a broader spectrum of patient presentations. Thus, in this meta-analysis, we measure the lifetime and current (12-month) prevalence of SUDs among adults with EDs to address this identified gap in the literature. Specifically, we explore the prevalence of pooled SUDs and ten specific subtypes of SUDs (including alcohol, cocaine, amphetamines, tobacco, cannabis, hallucinogens, inhalants, sedative-hypnotic-anxiolytics, opioids, and caffeine). We also examine how the prevalence of comorbid SUD varies by several demographic (age, sex, ethnicity), methodological (study setting, method of diagnosis), and diagnostic (specific ED or SUD diagnosis, and ED-subtype) variables known to influence SUD and ED prevalence.

2. Methods

2.1. Literature search strategy

This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). To identify pertinent studies, the following six databases were systematically searched: PubMed, MEDLINE, PsycINFO, CINAHL, Cochrane and EMBASE. The following types of search terms were used: eating disorder, substance-related disorder, prevalence, comorbidity. A full search strategy is provided in Supplementary Appendix 1. Searches were conducted in August 2017 from inception onwards; the initial search strategy was repeated in September 2018 to identify additional articles. As a complement to this search, we performed backward searches (i.e., examining reference lists of eligible studies).

Eligible articles measured the lifetime or current prevalence of SUD comorbidity in individuals with an ED. *Lifetime prevalence* was defined as the percentage of individuals who have ever met criteria for a substance use disorder; *current prevalence* was defined as the proportion that have met criteria over the past twelve months. Articles were not excluded on the basis of age, sex, geographic location, or ED or SUD subtype. However, non-English articles and those where ED and SUD diagnoses were not assessed were excluded.

A total of 1013 articles were identified. Following removal of duplicates, two co-authors (AB and MNM) completed two independent rounds of screening (first by title and abstract and then by full-text review). Discrepancies between authors were discussed and resolved by consensus after each round of screening.

Fig. 1 illustrates the results of the systematic literature process. In summary, 43 articles (41 reporting lifetime prevalence, 16 reporting current, 14 reporting both) met inclusion criteria. The number of total studies included in the analyses of moderators, however, varied due to missing data on some methodological and demographic characteristics.

2.2. Study coding

When necessary, one co-author (AB) contacted a study's corresponding author to clarify methodological/data details. Clarification was most often sought to determine if authors assessed lifetime or current prevalence of substance use disorders (n = 2 or 4.65% of included studies) and if studies differentiated between subtypes of eating disorders (n = 1 or 2.32% of included studies).

Study coding was initially performed by co-author AB and was later independently reviewed by EH; no between-author disagreements arose. The reference period (i.e., current or lifetime) of SUD diagnoses, the sample size, and the number of participants who met criteria for SUD were coded for each study to calculate the prevalence of SUDs. Studies reporting two independent samples (e.g., prevalence rates stratified by eating disorder subtype) were coded as separate entries (read: studies) but demarcated by Roman numeral in forest plots and Supplementary Appendix 2. For each study, the type of SUD was recorded on the basis of the indexed substance, under the following categories: any substance, alcohol, any illicit drug, amphetamine, cocaine, any stimulant, other, tobacco, cannabis, polysubstance (concurrent abuse of three or more substances), hallucinogens, sedative/hypnotic/anxiolytic, inhalant, opioid, or caffeine.

Additionally, moderators that could influence prevalence of SUD across studies were identified and included several variables: *demographic* (age [mean], total number of female participants, total number of male participants, and primary ethnicity of participants), *diagnostic* (recruitment setting [outpatient, inpatient, or both], substance use disorder assessment method [standardized interview or chart review], criteria used to make eating disorder diagnosis, and criteria used to

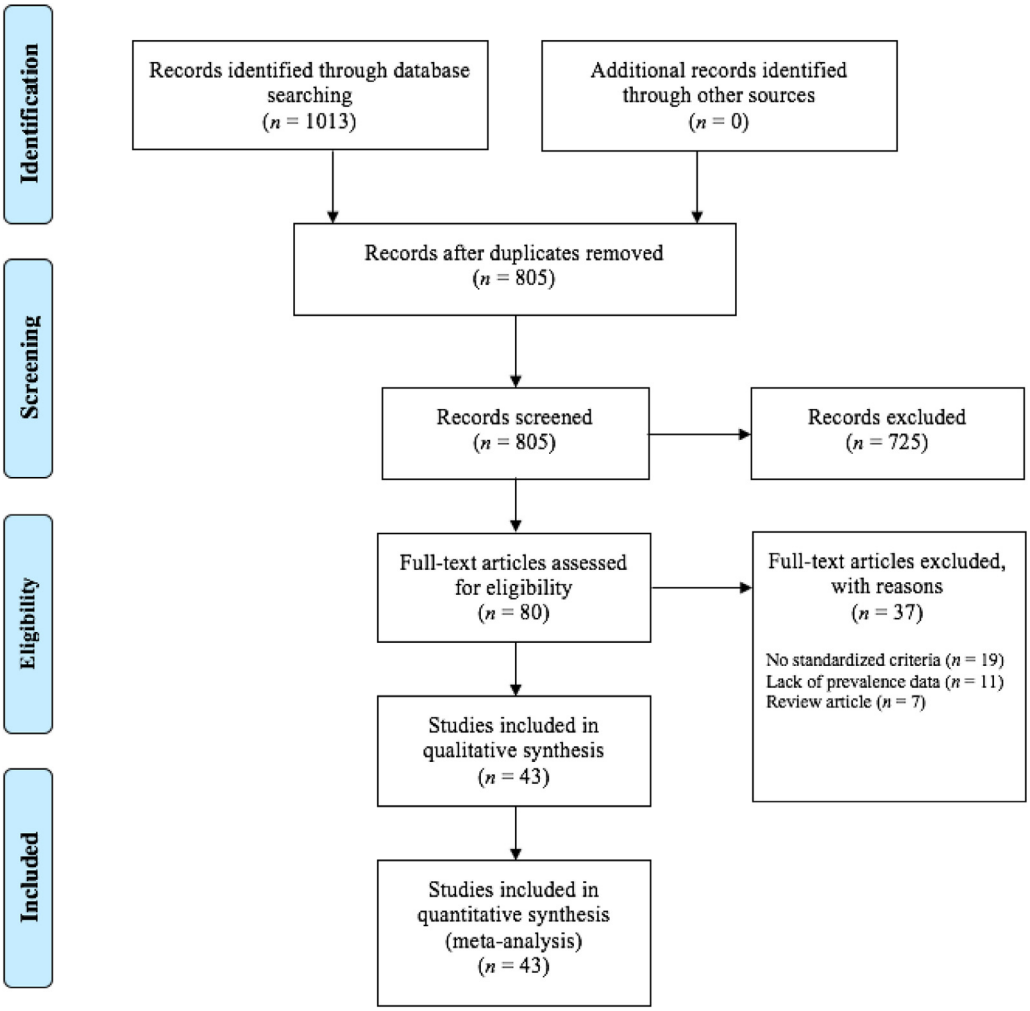

Fig. 1. PRSIMA flow diagram.

make substance use disorder diagnosis), and *methodological* variables (country of study, and year of publication). Criteria for eating disorder diagnoses included *DSM-III* (n = 60) and *DSM-IV* (n = 52); criteria for substance use disorder diagnoses included *DSM-III* (n = 58) and *DSM-IV* (n = 48).

2.3. Study quality

To assess study quality, the Risk of Bias tool (RoB) designed for studies reporting prevalence rates was used (Hoy et al., 2012). The detailed item and coding guide can be found in Supplementary Appendix 2. In brief, ten items on the RoB assess external and internal validity using forced choice response (yes/no). Each "yes" identified receives a score of 1 with a total possible score of ten ("no" responses are scored 0). Low risk of bias was defined as scoring ≥4 points while a high risk of bias was present if total scores were <4 points on the RoB. Two co-authors (AB and CH) independently scored studies using the RoB with no discrepancies identified between authors.

2.4. Data analysis

Of the 41 studies reporting lifetime prevalence of SUD in adults with ED, 28 reported on the occurrence of any form of SUD. All analyses were performed with the Comprehensive Meta-Analysis software (CMA; Borenstein et al., 2005). Prevalence (proportion) of SUD was calculated in studies that reported the number of individuals with eating disorder who also met criteria for a lifetime or current substance use disorder. The analysis primarily quantified the prevalence of any SUD rather than a particular substance, as the sample sizes of these studies was very small. Using CMA, prevalence was transformed into a logit event rate effect size with an associated standard error. When summarized, prevalence is reported (not logit event rate) for easy interpretation. Forest plots detail reported prevalence by study as well as the overall/pooled prevalence. Heterogeneity of the studies was assessed using Cochran's Q-test and Higgins I^2. Low heterogeneity was defined as Q scores < critical chi square values and I^2 < 25%; moderate if Q > critical chi square values and I^2 around 50%; and high if Q > critical chi square and I^2 > 50%. In the case of significant heterogeneity, random-effects models were used to determine pooled prevalence. Statistical significance was defined as $p < .05$.

2.5. Moderator analyses

Several moderators were identified to evaluate their contribution to SUD lifetime and current prevalence. Using CMA, the $Q_{between}$ statistic (analogous to analysis of variance) tested categorical variables to report between-study variance explained by moderators. If significant heterogeneity was present, mixed(random)-effects models were reported. A series of all possible two-group comparisons were conducted with Bonferroni correction to follow-up significant categorical moderators. Continuous moderators were analyzed using meta-regression. Interactions among moderator variables were not tested due to insufficient power.

2.6. Publication bias

Publication bias was assessed with funnel plot symmetry both visually and statistically, using Egger's linear regression method to assess any relationship between sample size and prevalence (Egger, Davey Smith, Schneider, & Minder, 1997). If significant funnel plot asymmetry was present, the trim and fill method was used to determine the number of missing studies that would be needed to correct the asymmetry (Duval and Tweedie, 2000). An additional quantitative assessment of bias used the Begg's rank method (Begg and Mazumdar, 1994) to identify relationships between effect sizes and sample sizes. Low publication bias was deemed present if funnel plots were visually symmetrical and were quantitatively statistically insignificant.

3. Results

3.1. Systematic review process

A total of 1013 citations were identified by the systematic review strategy (Fig. 1). After duplicate citations were removed, 805 citations remained. After initial screening on the basis of title and abstract, 80 citations remained. After full-text review, a total of 43 article were included final meta-analysis. Of the 43 articles, 41 assessed lifetime prevalence, 16 assessed current prevalence, and 14 assessed both lifetime and current prevalence. Individual studies often included several different groups of ED (e.g., patients with AN, BN, BED, etc.). In total, 112 independent patient samples were assessed across the 43 studies for prevalence of comorbid SUD.

3.2. Lifetime substance use disorder comorbidity

The overall lifetime prevalence of any SUD in individuals with ED was 25.4% (± 16.1%). The lifetime prevalence of individual types of SUDs is presented in Table 1. Tobacco (36.1 ± 23.1%), caffeine (23.8 ± 12.5%), alcohol (20.6 ± 16.0%), any illicit drug (19.8 ± 19.6%), cannabis (14.5 ± 16.0%), and cocaine (13.7 ± 23.4%) were among the most prevalent comorbid SUDs. Overall, studies had high heterogeneity (range = 3.2% to 67.7%, $I^2 = 96.13$, $Q = 698.12$, $p < .01$), necessitating random-effects modeling for pooled prevalence calculations. Fig. 2 illustrates the forest plot for the lifetime prevalence of any SUD in individuals with ED, which was 21.9% (95% CI: 16.7–28.0%).

Lifetime prevalence of any SUD was stratified by categorical moderator variables (Table 2). Coded moderator variables for each study are detailed in Supplementary Appendix 3. A high amount of heterogeneity remained in all moderator analyses ($ps < 0.001$) and mixed (random)-effects analysis of $Q_{between}$ is reported. Using univariate regression, neither the proportion of females in the sample nor the mean age were significant predictors of comorbid SUD (%female: $Q[1] = 0.19$, $p = .67$; age: $Q[1] = 0.35$, $p = .55$). However, when treated categorically (studies including all-female versus mixed studies with both males and females), the prevalence of SUD comorbidity was significantly higher in all-female studies (26%) compared to mixed studies (15%; Table 2). SUD prevalence was also significantly higher in studies with a primarily Caucasian sample (24%) compared to those with a primarily Asian sample (7%). As these were the only two primary ethnicities reported in the samples studying lifetime prevalence of comorbid SUD, we are not able to assess the impact of other ethnicities.

ED were classified into five categories: AN, BN, BED, EDNOS, and unspecified. The prevalence rate of SUD was significantly different between categories ($Q_{between}[4] = 12$, $p = .02$). Follow-up analysis with Bonferroni correction revealed a significantly higher prevalence of SUD in those diagnosed with BN compared to AN ($Q_{between}[1] = 7.0$, $p = .01$). Increased prevalence in BN also neared significance compared to EDNOS ($Q_{between}[1] = 5.1$, $p = .02$). No other between group comparisons were significant ($p > .05$).

ED diagnoses were also stratified by symptom presentation (binge/purge, restrictive, not specified behavior). Rates of SUD were significantly different across these symptom presentations ($Q_{between}[2] = 6.6$, $p = .04$). Further analysis indicated that prevalence rates of SUD were significantly higher in the binge-purge group than in the restrictive group ($Q_{between}[1] = 6.5$, $p = .01$). The restrictive group also tended toward being significantly lower than the not specified group ($Q_{between}[1] = 3.3$, $p = .07$).

Neither treatment setting ($p = .14$) nor SUD/ED assessment method ($p > .05$ for both) were significant moderators of SUD prevalence (Table 2). There were significantly different prevalence rates by SUD diagnostic criteria used ($Q_{between}[2] = 6.8$, $p = .033$). Follow-up analysis with Bonferroni correction indicated prevalence significantly differed only between DSM-III and DSM-IV SUD diagnostic criteria ($Q_{between}[1] = 6.1$, $p = .01$). For eating disorder diagnostic criteria, only two tools were used across studies – DSM-III and DSM-IV. A significant difference in SUD prevalence was evident between the two versions of the DSM ($Q_{between}[1] = 6.5$, $p = 0.01$) with significantly more SUD prevalent in those that used the DSM-III (29%, 95% CI: 22% − 38%) than the DSM-IV (16%, 95% CI: 11% − 23%).

3.3. Current substance use disorder prevalence

The current prevalence of individual types of SUDs is also presented in Table 1. Cocaine (28.5 ± 28.8%), cannabis (20.9 ± 12.0%), tobacco (15.3 ± 9.1%), and opioids (11.0 ± 7.8%) were among the

Table 1
Lifetime and current (12-month) prevalence of co-morbid DSM-IV substance use disorders (%) with DSM-IV eating disorders.

	Lifetime (samples)	Lifetime Prevalence (mean, SD)	Current (samples)	Current Prevalence (mean, SD)
Any SUD	29	25.4% (± 16.1%)	7	12.9% (± 17.1%)
Alcohol	72	20.6% (± 16.0%)	16	7.2% (± 9.1%)
Any Drug	34	19.8% (± 19.6%)	6	9.8% (± 11.1%)
Amphetamine	18	6.3% (± 9.6%)	2	0% (± 0%)
Cocaine	21	13.7% (± 23.4%)	5	28.5% (± 28.8%)
Any Stimulant	9	8.2% (± 3.9%)	4	1.6% (± 1.5%)
Other	15	10.8% (± 14.5%)	1	0% (± 0%)
Tobacco	14	36.1% (± 23.1%)	7	15.3% (± 9.1%)
Cannabis	31	14.5% (± 16.0%)	9	20.9% (± 12.0%)
Polysubstance	14	8.6% (± 7.9%)	6	2.2% (± 1.5%)
Hallucinogens	17	4.7% (± 5.9%)	2	0% (± 0%)
SHA	23	6.6% (± 6.4%)	7	2.8% (± 1.1%)
Inhalant	10	0.4% (± 0.9%)	2	0% (± 0%)
Opioid	20	6.2% (± 6.4%)	7	11.0% (± 7.8%)
Caffeine	8	23.8% (± 12.5%)	0	0% (± 0%)

Abbreviations: SD – standard deviation; SUD – substance use disorder; SHA – sedative/hypnotic/anxiolytic

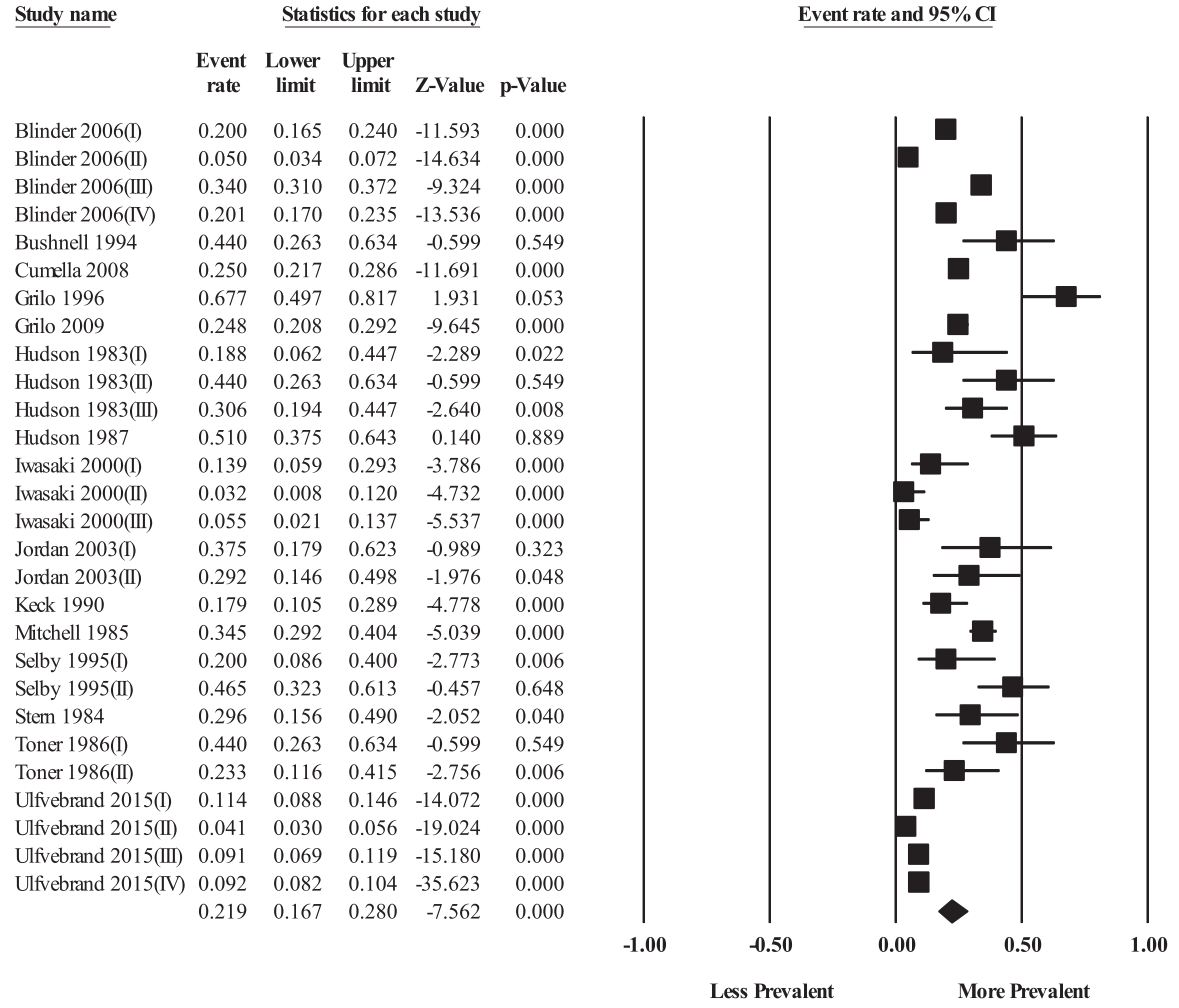

Fig. 2. Forest plot of lifetime prevalence of substance use disorder in individuals with eating disorder.

most prevalent comorbid SUDs. The 7 studies identifying any current SUD had moderate to high heterogeneity (range = 0.0% to 44.0%, I^2 = 89.40, Q = 56.59, p < .001). Thus, random-effects modelling calculated pooled prevalence rates. Fig. 4 illustrates the forest plot for the current prevalence of SUD in adults with ED. The pooled current prevalence of any SUD in adults with ED was 7.7% (95% CI: 2.0–25.8%). Current prevalence of SUD was stratified by categorical moderator variables (Table 2; Coded moderator variables for each study are detailed in Supplementary Appendix 4). A high amount of heterogeneity remained in all moderator analyses (*ps* < 0.001) and mixed(random)-effects analysis of $Q_{between}$ is reported.

Using univariate regression, neither the proportion of females in the sample (Q[1] = 1.7, p = .19), nor mean age (Q[1] = 0.70, p = .40), was predictive of current SUD prevalence. However, when treated categorically (studies including all-female versus mixed studies with both males and females), prevalence of SUD was significantly higher in all-female studies (11%) versus mixed studies (2.7%). Studies examining current SUD only contained primarily Caucasians participants. Studies examining current SUD prevalence only identified three subcategories of eating disorders (AN, BN, and BED), and prevalence did not differ among these subcategories, or between binge/purge and restrictive ED behaviors (Table 2). All studies examining current SUD included only outpatients and used a structured clinical interview to diagnosis both eating disorders and SUDs (Table 2). Only the DSM-III and DSM-IV were used to diagnose SUD. Prevalence did not vary by diagnostic tool ($Q_{between}$[1] = 0.47, p = .49). As well, only DSM-III and DSM-IV were used to diagnosed EDs, and there was no difference in SUD prevalence between the two versions of the DSM ($Q_{between}$[1] = 0.47, p = .49).

3.4. Publication bias

Visual assessment of the funnel plot for the lifetime prevalence of comorbid SUDs (Fig. 3) suggests little publication bias (i.e., it is symmetrical). Quantitative assessments of publication bias were also not significant (p > .05 for Begg's rank correlation analysis; p > .05 for Egger's weighted regression analysis) confirming low publication bias in included studies. However, visual assessment of the funnel plot for the current prevalence of comorbid SUDs shows slight asymmetry (Fig. 5), suggesting publication bias may be present. However, quantitative measures of publication bias were not statistically significant (Egger's weight regression analysis, p > .05; Begg's rank correlation analysis, p > .05), indicative of low publication bias.

4. Discussion

This meta-analysis presents the lifetime and current prevalence of SUD comorbidity among individuals with ED. Forty-three studies were included: 41 examined lifetime prevalence and 7 examined current prevalence. The pooled lifetime prevalence of any SUD was 21.9% (95% Confidence Interval [CI]: 16.7–28.0%), while the current prevalence was 7.7% (95% CI: 2.0–25.8%). Tobacco (36.1 ± 23.1%), caffeine (23.8 ± 12.5%), and alcohol (20.6 ± 16.0%) were the most prevalent comorbid SUDs. Lifetime SUD comorbidity was higher among females, Caucasians, individuals with BN and binge-purge behaviors,

Table 2
Moderator analysis for the comorbidity of lifetime and current (12-month) DSM-IV substance use disorders in DSM-IV eating disorders.

	Lifetime prevalence			Current (12-month) prevalence		
	Prevalence	95% CI	Studies (n)	Prevalence	95% CI	Studies (n)
Age						
25 and under	19%	13–27	16	8.8%	1.0–48	2
26 and older	26%	18–36	12	7.3%	1.3–33	5
Sex[*,‡]						
All-female	26%	20–32	20	11%	3.5–31	6
Mixed	15%	9.4–23	8	2.7%	1.5–4.8	1
Ethnicity[*]						
Asian	7.0%	3–16	3	–	–	–
Caucasian	24%	24–18	25	7.7%	2–26	7
Eating disorder[*]						
Anorexia nervosa	13%	11–14	13	12%	2.6–43	4
Bulimia nervosa	34%	32–36	9	6.0%	0.2–72	2
Binge eating disorder	18%	15–20	2	2.7%	1.5–4.8	1
Eating disorder not otherwise specified	12%	11–13	2			
Unspecified	27%	24–31	2			
Behavior[*]						
Binge/purge	26%	20–34	17	11%	2.4–40	5
Restrictive	11%	5.6–21	7	1.8%	0.3–12	2
Not specified	25%	13–42	4			
Setting						
Inpatient	26%	17–36	7	–	–	–
Outpatient	19%	13–27	18	7.7%	2–26	7
Mixed	32%	22–46	3	–	–	–
Method						
Chart review	23%	15–33	7	–	–	–
Structured clinical interview	22%	16–29	21	7.7%	2–26	7

[*] significant at 0.05 level, two-tailed, for lifetime;
[‡] significant at 0.05 level, two-tailed, for current prevalence.

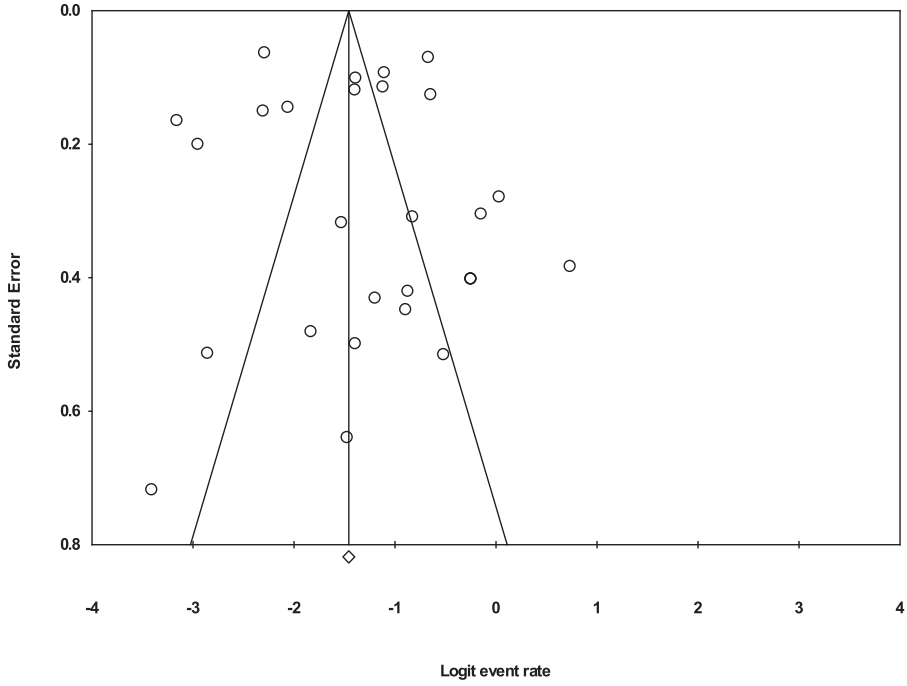

Fig. 3. Funnel plot of lifetime prevalence of substance use disorders in individuals with eating disorders.

while current SUD comorbidity was higher only in females. As previous studies have focused strictly on pooled, alcohol, or illicit drug SUD prevalence, our study's inclusion of ten SUD subtypes improves the comprehensive evidence on ED comorbidity.

Compared to the general Canadian adult population, the lifetime prevalence of SUD comorbidity we report here was similar (21.6%), while the current prevalence was almost double (4.4%) (Statistics Canada, 2013). Compared to the general United States adult population, the rates of lifetime and current SUD are 14.6% (Kessler et al., 2005) and 3.8% (Kessler et al., 2005), respectively. In other psychiatric disorders, the prevalence of comorbid SUDs is significantly elevated (Kessler et al., 1996). In major depression and anxiety disorders, the 12-month prevalence of comorbid SUDs ranges from 18.4%−37.1%, and 13.5–21.0%, respectively (Kessler et al., 1996). For lifetime prevalence, 50.9% of individuals with one or more mental health disorders have one or more SUDs. Lifetime prevalence of comorbid SUDs is highest among individuals with conduct disorder and antisocial personality disorder (82.1%), and significantly less among

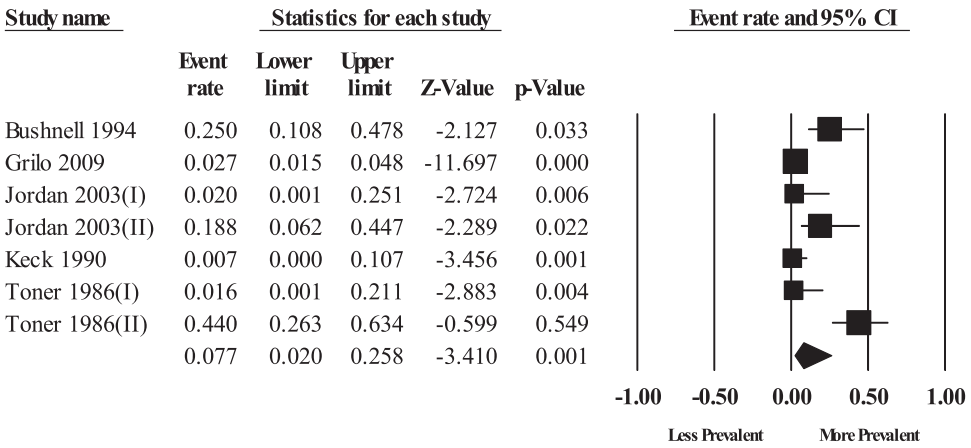

Fig. 4. Forest plot of current prevalence of SUD in adults with eating disorder.

individuals with mood (41.2%) or anxiety (37.8%) disorder (Kessler et al., 1996). Together, this research suggests that SUD may be an important phenotype of some mental illness but not others (Holderness et al., 1994).

Several moderators known to influence SUD and/or ED prevalence were examined. Most notably, our meta-analysis identified an association between SUD and BN and binge-purging behavior compared to other ED diagnoses and ED behaviors. This supports previous literature indicating that individuals with BN and binge-purge disorders are more likely to struggle with SUD, which has been linked to greater difficulties with emotion regulation and impulse control (Calero-Elvira et al., 2009; Grilo et al., 1995; Spindler and Milos, 2007). This association, however, was not present in current SUD prevalence, most likely due to the small number of studies identified. Age was not associated with the prevalence of SUD in our study. Although our study may have been underpowered to identify age differences, this finding is consistent with existing literature indicating age is not linearly related to the prevalence of SUD in the general population (Schulte and Hser, 2014). While substance use is often initiated in adolescence, it is during middle adulthood that prevalence rates for SUD peak (Schulte and Hser, 2014) and then declines in older adults (Center for Substance Abuse Treatment, 1998). The finding that all-female samples were associated with a significantly higher prevalence of comorbid SUD is difficult to explain as it is known that SUD are more prevalent among males (Kessler et al., 2005). Due to a gross underrepresentation of males in existing ED literature, there were few identified studies exploring comorbidity in males with ED. Hence, our study may have been underpowered to find sex differences. Finally, SUD comorbidity was greater in studies using *DSM-III* criteria (compared to *DSM-IV*), which suggests that the *DSM-III* has a relatively lower threshold for diagnosing SUD. This may be related to the specific criteria used across diagnostic texts. However, SUD comorbidity was not higher in studies using structured clinical interviews (SCI). While SCI are reliable for assessing the most common psychiatric disorders (Miller et al., 2001), this finding has not been established in the ED population. This may also be explained by the finding that individuals with ED often underestimate their impairments compared to informant-reports, which may result in biased SUD prevalence estimates (Keski-Rahkonen et al., 2006). Therefore, the diagnostic reliability could be improved further by incorporating collateral from multiple informants (Forman et al., 2004; Kranzler et al., 1995).

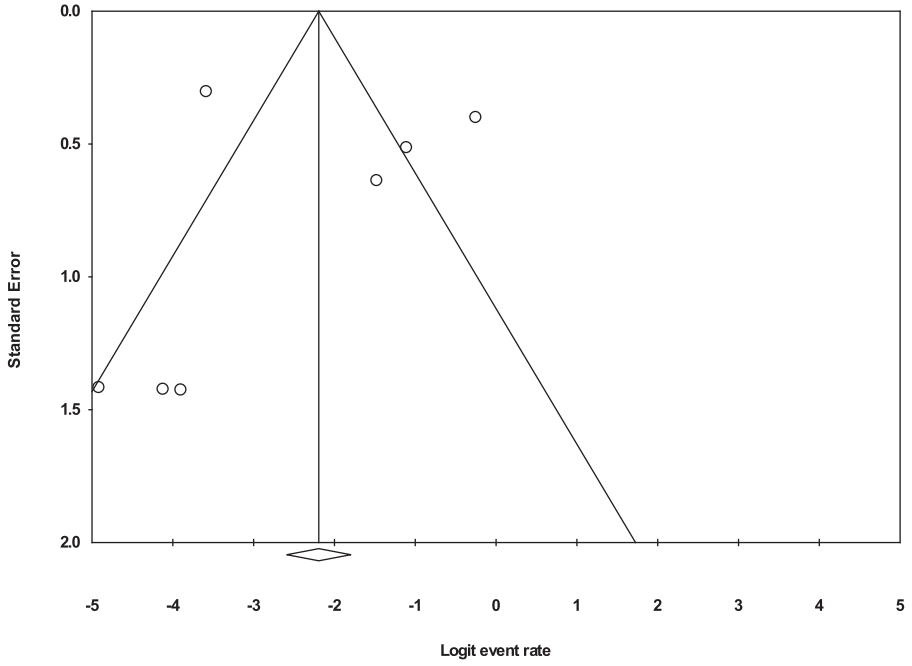

Fig. 5. Funnel plot of current prevalence of substance use disorders in individuals with eating disorders.

5. Strengths and limitations

This study's strengths include a methodologically rigorous, comprehensive, and PRISMA-adherent approach. As studies were not excluded based on their geographic location, our findings may be more generalizable to the global ED population. The study identified comorbid SUD diagnoses rather than symptoms or 'substance use', and thus, the identified results represent the presence of a clinically significant psychiatric comorbidity.

Although out meta-analysis focused on comorbidity with formal SUD diagnoses, the exclusion of studies measuring SUD symptoms limited our results in two ways. First, SUD symptoms in the absence of a clinical diagnoses can still cause significant functional impairment, especially if the individual endorses one symptom less than is required for a diagnosis. Second, there may be differential associations between certain SUD symptoms and eating disorder diagnoses/subtypes that are undetected in individual studies yet may be detected in a combined sample. As is demonstrated in prior studies and replicated in the current study, the eating disorder symptoms of binge eating and/purging are important in this association – and perhaps a similar finding exists at the SUD symptom level.

Additionally, a limitation of this study is the smaller sample size for current SUD prevalence and moderator variables, which may have contributed to suboptimal power for statistical analyses. As with all meta-analyses, we were limited by the quality and quantity of existent studies, and our results reflect only what is available in terms of existing literature. On average, the participants included in the current meta-analysis were young (M_{age} = 26.9 years old) and female (96.0% female). Consequently, the overall prevalence estimates presented in the current study are not representative of all individuals with ED. Future research is needed to better understand the prevalence of SUD in subgroups of individuals ED, especially males, children and adolescents, and the elderly.

6. Conclusions

Roughly one in five individuals with an ED will develop a SUD at some point in their lifetime and roughly one in ten will meet current criteria for a SUD. Results from this meta-analysis highlight that some ED subtypes are associated with specific behaviors (e.g., binging and purging behaviur), which are linked with a higher prevalence of SUD. Clinicians should be aware that all categories of SUD are highly prevalent in this population (not just alcohol) and that the impairments associated with an ED may be compounded by the presence of additional psychiatric comorbidities (Braun et al., 1994; Kaye et al., 2004). Clinicians should be particularly cognizant of SUD potential in Caucasian patients presenting with binging and purging behaviors, as they appear to be at greater risk for developing a SUD. Regular screening for psychiatric comorbidity may help facilitate access to evidence-based treatments and prevent compounding the disability associated with the eating disorder (Holderness et al., 1994; Nøkleby, 2012). Future research should focus on the epidemiology of ED among males, particularly, and their specific patterns of comorbidity.

Declarations

Conflict of interest: the authors declare that they have no conflicts of interest.

Ethical approval: meta-analyses are exempt from research ethics board review because the data is collected from publicly available information.

Informed consent: because the study did not involve interaction with participants, informed consent was not required.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2019.01.007.

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