

## ORIGINAL ARTICLE

# Suicidality risk among adults with binge-eating disorder

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## Abstract

**Objective:** To estimate relative suicidality risk associated with binge-eating disorder (BED).

**Methods:** Retrospective study of patients identified as having BED ( $N = 1042$ ) and a matched general population cohort ( $N = 10,420$ ) from the Optum electronic health record database between January 2009 and September 2015. Patients had  $\geq 1$  outpatient encounter with a provider who recognized BED during the 12-month baseline preceding entry date. Incidence and relative risk of suicidality were assessed.

**Results:** Incidence per 1000 person-years (95% CI) of suicidal ideation and suicide attempts, respectively, was 31.1 (23.1, 41.0) and 12.7 (7.9, 19.4) in the BED cohort and 5.8 (4.7, 7.1) and 1.4 (0.9, 2.2) in the comparator cohort. Risk of suicidal ideation and suicide attempts was greater in the BED cohort (HR [95% CIs], 6.43 [4.42, 9.37]) than in the comparator cohort (HR [95% CI], 9.47 [4.99, 17.98]) during follow-up. After adjusting for psychiatric comorbidities, associations of suicidal ideation and suicide attempts with BED remained elevated in patients with BED having histories of suicidality.

**Conclusions:** Findings suggest that history of suicidality may result in an increased risk of suicidal ideation and suicide attempts in patients with BED relative to the general population. Psychiatric comorbidity burden may explain the elevated risk of these conditions in BED.

## KEY WORDS

binge-eating disorder, suicide, suicidal ideation, suicide attempts

## INTRODUCTION

Binge-eating disorder (BED) is the most common eating disorder (Hudson et al., 2007; Kessler et al., 2013; Udo & Grilo, 2018). In an epidemiologic study based on the World Health Organization World Mental Health Surveys, 12-month and lifetime prevalence estimates of *Diagnostic and Statistical*

*Manual of Mental Disorders, Fourth Edition (DSM-IV)*-defined BED, respectively, across 14 countries were 0.8% and 1.9% (Kessler et al., 2013). A study based on the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC-III) reported 12-month and lifetime prevalence estimates of *DSM-5*-defined BED in the United States, respectively, of approximately 0.4% and 0.9% (Udo & Grilo, 2018).

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Adults diagnosed with BED can experience multiple comorbid psychiatric disorders (Carano et al., 2012; Grilo et al., 2009, 2013; Guerdjikova et al., 2007; Jones-Corneille et al., 2012; Kessler et al., 2013; Pisetsky et al., 2013; Schulz & Laessle, 2010). Mood and anxiety disorders are among the most frequently reported psychiatric disorders (Grilo et al., 2009, 2013; Guerdjikova et al., 2007; Jones-Corneille et al., 2012; Kessler et al., 2013; Schulz & Laessle, 2010), and individuals diagnosed with BED are also at increased risk for suicidal thoughts (i.e., thinking about, considering, or planning suicide [i.e., suicidal ideation]) and behaviors (i.e., when someone harms themselves with the intent to end their life [i.e., suicide attempts]; Brown et al., 2018; Pisetsky et al., 2013; Udo et al., 2019; Welch et al., 2016). In a survey of US households, 37.5% of adults with BED had a history of suicidality versus 19.3% of individuals who were not diagnosed with BED (Brown et al., 2018). In the general population of US adults, as measured by the 2016 National Survey on Drug Use and Health, 4.0% of respondents indicated that they had considered suicide (Substance Abuse & Mental Health Services Administration, 2017). Furthermore, in a retrospective cohort study of Swedish national population registry data, suicide attempts/completions were identified in 5.8% of individuals diagnosed with BED compared with 1.6% of matched controls who were not diagnosed with BED (Welch et al., 2016).

Prior to 2016, the International Classification of Diseases, 10th Revision (ICD-10) did not include an independent diagnostic code for BED. Therefore, it was not possible to identify patients with BED using diagnostic codes in administrative healthcare databases (i.e., databases containing healthcare information generated through interactions with healthcare professionals and medical/insurance claims). However, using natural language processing (NLP) of clinical notes (i.e., digital analysis of clinical notes from patient records), the characteristics and healthcare burden of patients identified as having BED from the Department of Veterans Affairs database were described (Bellows et al., 2014, 2015, 2016). In the current study, NLP algorithms were used to identify patients with BED from a large, geographically diverse US administrative healthcare electronic health record (EHR) database and the incidence and relative risk of suicidal ideation and suicide attempts were examined. For the assessment of relative risk, the impact of several variables (e.g., psychiatric disorders, smoking, physical activity, and body mass index [BMI]) on the associations between suicide risk and BED was examined based on previous reports of their association with suicide (Bachmann, 2018; Forrest et al., 2017; Gunnell & Frankel, 1994; Perera et al., 2016; Poorolajal & Darvishi, 2016; Vancampfort et al., 2018).

## METHODS

### Study design, data source, and patient identification

This retrospective cohort study identified patients with BED using NLP of clinical notes from January 1, 2009, to September 30, 2015, from the Optum EHR database (Optum, Eden Prairie, MN). The baseline period included the 12 months before and including the cohort entry date, with the cohort entry date defined as the date of first identification of BED during the study period. Based on this definition, the cohort entry date was not necessarily the date of first BED recognition by a healthcare provider because some patients may have had preexisting BED before the beginning of the study.

The Optum EHR database is a patient-level database that integrates US electronic medical records from providers and hospital networks. The database includes data from >36.5 million patients from 2007 through 2014, with 18.4 million patients having  $\geq 1$  encounter in 2014. This database integrates multiple data systems with medical claims, prescription, and practice management data from both ambulatory and inpatient settings, including medical records, laboratory results, drug prescriptions (including the number of refills), and administrative data. All provider types (primary care, mental health, surgery, etc) are included. Additional information regarding the Optum EHR database can be found in Methods S1.

Patients included in the analyses were  $\geq 18$  years old and had  $\geq 1$  outpatient encounter with a healthcare provider during the 12-month baseline period who would recognize BED and who contributed notes to the database. Because a specific ICD, 9th Revision (ICD-9) code for BED was not available during the study period, BED was categorized under code 307.50 (Eating Disorder, Not Otherwise Specified). Therefore, patients were identified using algorithms comprised mainly of NLP terms (see Methods S2). Separate algorithms (Figure S1) used combinations of NLP terms to identify two patient cohorts: a BED cohort, which met more stringent BED criteria (e.g., having  $\geq 2$  affirmations of “binge-eating disorder” or 1 affirmation of “binge-eating disorder” plus an affirmation of “binge eating” within a single note), and a probable BED cohort, which met less stringent criteria (e.g., having only 1 affirmation of “binge-eating disorder” or  $> 2$  neutral mentions of “binge-eating disorder” within a single note).

The research staff followed all applicable laws and regulations, used deidentified data, and maintained the confidentiality of patient records. The publicly available Optum EHR database has been certified as deidentified by the statistical alternative method to comply with privacy provisions

of the Health Insurance Portability and Accountability Act of 1996 and of the American Recovery and Reinvestment Act of 2009. The protocol was reviewed by an Optum ethics review committee to assure the data could not be used to re-identify patients. An institutional review board review was not required because the study used deidentified data. All study procedures followed the principles outlined in the Declaration of Helsinki.

## Identification of suicidality

Suicidal ideation and suicide attempt events were identified using a combination of NLP terms and ICD-9 codes. Analysis of suicidal ideation was based on ICD-9 code V62.84 combined with NLP terms that included “suicide,” “suicide prevention,” “death ideation,” “suicide ideation,” “suicide risk,” and “suicidal/homicidal ideation.” Analysis of suicide attempts was based on a previously published and validated algorithm (Barak-Corren et al., 2017) and used ICD-9 codes E95X.X, 965.XX, 967.X, 969.XX, and 881.XX combined with NLP terms that included “committed suicide,” “completed suicide,” “suicide attempt,” and “suicide.” These listings of ICD-9 codes and NLP terms for suicidal ideation and suicide attempts, respectively, represented the suicidal ideation and suicide attempt algorithms. Patients were considered to have had a suicidal event (an instance of suicidal ideation or suicide attempts [completed or not completed]) if they met algorithm criteria on  $\geq 2$  dates within 2 months. The date of a suicide attempt was set to the earlier event; the date of a suicidal ideation event was set to the earliest occurrence of a suicidal ideation or a suicide attempt. Linkage to death records was not available so completed suicides were not assessed.

## Data analysis

Data are reported for the BED cohort, probable BED cohort, all BED cohort (BED + BED probable), and a propensity score-matched general population comparator cohort (i.e., a cohort matched [10:1] to patients with BED using a propensity score comprised of age, sex, region, race/ethnicity, and four cohort entry date calendar periods). Demographic and lifestyle characteristics and psychiatric comorbidities during baseline are reported descriptively.

The incidence (per 1000 person-years) of suicidal ideation and suicide attempts was calculated for all cohorts by dividing the number of instances of each suicidal event by the number of person-years of at-risk follow-up. For suicidal ideation, follow-up began at the entry date and ended at the first of the following: a suicidal ideation event, a suicide attempt, loss to follow-up, death, or end of the study period. For suicide attempts, follow-up began at the entry date and

ended at the first of the following: a suicide attempt, loss to follow-up, death, or end of the study period. Patients were considered lost to follow-up if  $\geq 2$  years elapsed following their last recorded encounter. These data are presented with Poisson's exact 95% CIs.

Incidence was also calculated in selected subgroups of patients from the BED cohort. These subgroups were defined based on the presence or absence of attention-deficit/hyperactivity disorder (ADHD) during baseline or having had versus not having had bariatric surgery during baseline. ADHD was identified using ICD-9 code 314.0X. Bariatric surgery was identified using Current Procedural Terminology codes (43644–43645, 43770–43775, 43842–43848, and 43886–43999) and ICD-9 codes (539.XX and V45.86).

The impact of several variables on the associations between suicide risk and BED was examined based on previous reports of their relationship to suicide risk (Bachmann, 2018; Forrest et al., 2017; Gunnell & Frankel, 1994; Poorolajal & Darvishi, 2016; Vancampfort et al., 2018). Associations between BMI and age with suicide risk in the all BED cohort were examined using logistic regression, with an indicator for missing BMI included in the model. To improve the statistical stability within the regression models, the single patient with BED who was underweight was classified as normal weight for the purpose of this analysis. Cox proportional hazards regression analyses stratified by matched set (patient with BED and 10 controls) generated hazard ratios (HRs) to estimate the association between BED and suicide risk in the all BED cohort relative to the general population cohort. Variables that could influence suicide risk (smoking status, physical activity level, and psychiatric disorders) were included in separate models (Bachmann, 2018; Forrest et al., 2017; Gunnell & Frankel, 1994; Poorolajal & Darvishi, 2016; Vancampfort et al., 2018). As the goal of these analyses was to examine the association between BED and risk of suicide events, the potential influence of specific psychiatric disorders was not examined. Consistent with standard approaches for identifying potential confounding variables (Patrick et al., 2011), confounding variables with a prevalence  $< 5\%$  were not expected to have a significant influence (i.e., they do not introduce significant bias) and were excluded from the multivariable HR models. Correlations for all selected covariates were examined, and no two variables with Spearman's correlation coefficients  $> 0.4$  were included in the same model.

## RESULTS

### Algorithm performance

Positive predictive values (PPVs, the number of confirmed BED patients divided by the total number of

algorithm-identified patients) of the algorithms were determined based on a subset of 173 patients. The PPVs (95% CI) for the BED cohort and probable BED cohort, respectively, were 83% (61%, 95%) and 64% (44%, 81%). The PPV (95% CI) for suicidal ideation was 75% (43%, 95%) and for suicide attempts was 27% (6%, 61%).

## Patient demographics

Table S1 summarizes baseline characteristics. Most patients were women (all BED, 80.8%; general population cohort, 80.5%) and white (all BED, 87.1%; general population cohort, 87.7%). In the all BED cohort, most patients (83.4%) met criteria for obesity (BMI  $\geq 30$  kg/m<sup>2</sup>), whereas only 37.2% of patients in the general population cohort had a BMI  $\geq 30$  kg/m<sup>2</sup>. The mean  $\pm$  SD age of patients was 45.6  $\pm$  13.0 years in the all BED cohort and 46.3  $\pm$  12.9 years in the general population cohort. The all BED and the general population cohort were well balanced across matching factors (Table S1). The most frequently reported psychiatric comorbidities across BED cohorts were major depressive disorder and anxiety/dissociative/somatoform disorder (Table S2).

## Frequency and incidence of suicidal ideation and suicide attempts

During baseline, the prevalence of suicidal ideation was 19.0% (73/384) in the BED cohort (probable BED, 9.9% [65/658]; all BED, 13.2% [138/1042]) and 2.2% (232/10,420) in the general population cohort. The prevalence of suicide attempts was 7.6% (29/384) in the BED cohort (probable BED, 4.6% [30/658]; all BED, 5.7% [59/1042]) and 0.6% (59/10,420) in the general population cohort. Incident suicidal ideation and suicide attempts during follow-up are summarized in Table S3. During follow-up, the incidence of suicidal ideation and suicide attempts was greater in all BED cohorts compared with the general population cohort, and was greater among patients with BED with versus without a history of ADHD and who did versus did not have bariatric surgery during baseline (Figure 1).

## Association of BMI and age with suicide risk

In the all BED cohort, obesity was associated with lower risk of suicidal ideation and suicide attempts than having normal weight (Table 1). However, among 1003 patients in the all BED cohort with a recorded BMI, continuous BMI was not associated with increased risk of suicidal ideation or suicide attempts. Age was not associated with increased suicidality

risk in the all BED cohort when assessed as a continuous or categorical variable.

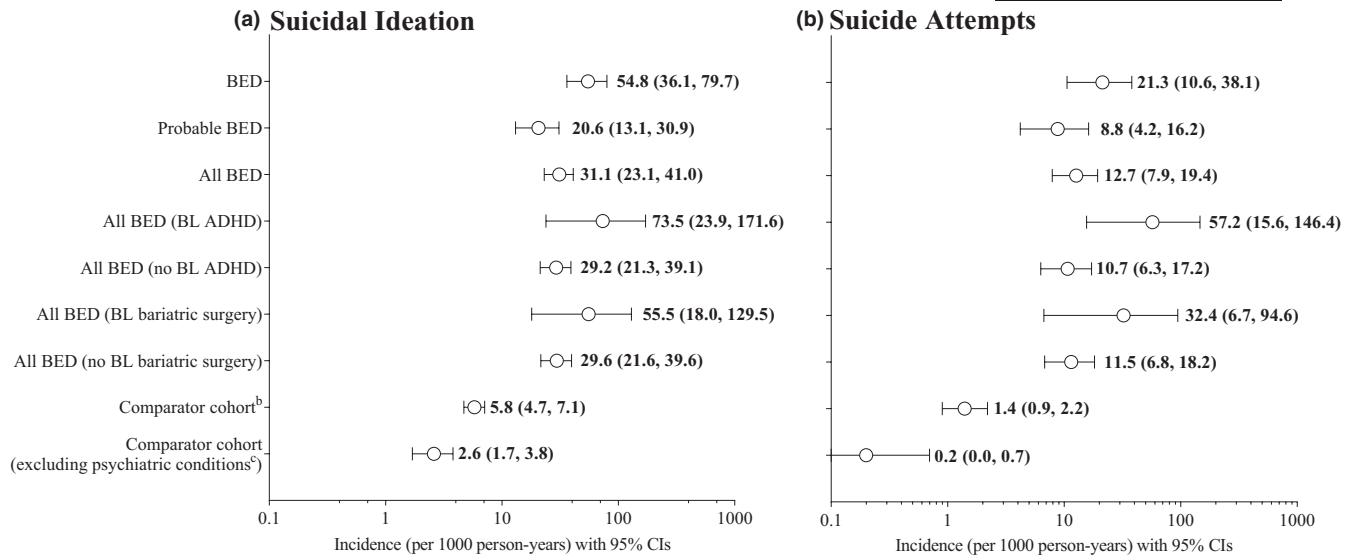
## Relative suicide risk

The all BED cohort had a greater risk of suicidal ideation and suicide attempts relative to the general population cohort, regardless of suicidality history at baseline (Table 2). Additional adjustment for smoking status and physical activity level did not alter risk for suicidal ideation and suicide attempts (Table 2). With further adjustment for psychiatric comorbidities (Table 2), there was no association between BED and risk of suicidal ideation or suicide attempts among patients with BED without a history of suicidality at baseline.

## DISCUSSION

These findings indicate that patients with BED had an increased risk of previous and incident suicidal ideation and suicide attempts relative to a general population cohort. The estimated incidence of suicidal ideation and suicide attempts was higher among patients with BED who had histories of ADHD or bariatric surgery during baseline relative to those who did not. The relative suicide risk among patients with BED was increased relative to the general population cohort. However, among patients with BED without a history of suicidality, there was no association between BED and suicidality risk after adjustment for psychiatric comorbidities.

These findings are consistent with previous reports of increased suicidality risk in individuals with BED (Brown et al., 2018; Carano et al., 2012; Pisetsky et al., 2013; Udo et al., 2019; Welch et al., 2016). In a twin study based on the Swedish National Patient Register and Cause of Death Register, risk of lifetime suicide attempts was significantly greater in women with *DSM-IV*-defined BED than in women without an eating disorder (Pisetsky et al., 2013). In another study using Swedish national population registry data, individuals with BED had significantly elevated suicide risk compared with a matched population after controlling for the presence of major depressive disorder (Welch et al., 2016). In a US-based epidemiologic study, the adjusted odds ratio for suicide attempts was significantly higher in individuals with BED relative to respondents without specific eating disorders (Udo et al., 2019). As the frequency of suicidal ideation and suicide attempts in the general population cohort in this study (2.2% and 0.6%, respectively) was comparable to the reported 12-month prevalence in another study of US adults (3.3% and 0.6%, respectively; Kessler et al., 2005), these findings indicate that BED is associated with a substantially higher suicide risk (suicidal ideation, 4.5- to 8.6-fold higher; suicide attempts, 7.7- to 12.7-fold higher) relative to the



**FIGURE 1** Incidence of (A) suicidal ideation and (B) suicide attempts. <sup>a</sup>ADHD, attention-deficit/hyperactivity disorder; BED, binge-eating disorder; BL, baseline; ICD-9, International Classification of Diseases, Ninth Revision. <sup>a</sup>First incidence of suicidal ideation or suicide attempt by natural language processing affirmation or ICD-9 code (January 1, 2009, to September 30, 2015). <sup>b</sup>Matched 10:1 to patients with BED for age, sex, geographic region, race/ethnicity, and calendar period of the cohort entry date. <sup>c</sup>Excludes the following diagnoses (ADHD; bipolar disorder; body dysmorphic disorder; dysthymia; general anxiety disorder; social anxiety disorder; obsessive-compulsive disorder; major depressive disorder; posttraumatic stress disorder; anxiety, dissociative, or somatoform disorder; anorexia nervosa; bulimia nervosa; eating disorder not otherwise specified) and medications (antidepressants, psychostimulants, anticonvulsants, antiobesity agents) during the baseline period

**TABLE 1** Association of BMI and age with suicidal ideation and suicide attempts in the all BED cohort

	Suicidal ideation <sup>a</sup> OR (95% CI)	Suicide attempts <sup>b</sup> OR (95% CI)
<b>BMI<sup>c</sup></b>		
Continuous BMI, <i>n</i> = 1003	1.00 (0.97, 1.02)	0.98 (0.94, 1.03)
Overweight vs. normal weight, <i>n</i> = 1042	0.85 (0.26, 2.76)	0.25 (0.05, 1.44)
Obesity vs. normal weight, <i>n</i> = 1042	0.34 (0.13, 0.92)	0.18 (0.06, 0.56)
<b>Age</b>		
Continuous age (per each additional year), <i>n</i> = 1042	1.00 (0.98, 1.02)	1.00 (0.97, 1.04)
Categorical (relative to 18–29 years old), <i>n</i> = 1042		
30–39 years	0.41 (0.14, 1.18)	0.96 (0.16, 5.83)
40–49 years	0.97 (0.42, 2.23)	2.09 (0.44, 9.97)
50–59 years	0.49 (0.19, 1.23)	1.38 (0.27, 6.90)
≥60 years	0.82 (0.31, 2.18)	0.93 (0.13, 6.70)

Abbreviations: BED, binge-eating disorder; BMI, body mass index; OR, odds ratio.

<sup>a</sup>There were 50 incident suicidal ideation events in the all BED cohort.

<sup>b</sup>There were 21 incident suicide attempt events in the all BED cohort.

<sup>c</sup>Normal (18.5 to <25 kg/m<sup>2</sup>), overweight (25 to <30 kg/m<sup>2</sup>), and obesity (≥30 kg/m<sup>2</sup>).

general population. Therefore, it is important that physicians remain clinically vigilant for signs of potential suicide risk in patients diagnosed with BED.

The current analyses indicate that patients with BED having an ADHD diagnosis or bariatric surgery during baseline have a higher incidence of suicidal ideation and suicide attempts compared with those who did not. For both ADHD and BED, impulsivity may be an important factor mediating

suicide risk. In a study of inpatients with psychiatric disorders who had made a suicide attempt, a significant positive association between impulsivity and attempted suicide was reported (Bhatt et al., 2018). In another study of adults who had attempted suicide, increased impulsivity and aggression were associated with increased risk of suicide attempts at an early age, particularly in adults with probable ADHD (Conejero et al., 2019). Furthermore, in adult psychiatric outpatients,

TABLE 2 Association between BED and risk of suicidal ideation and suicide attempts

	Suicidal ideation, HR (95% CI)		Suicide attempts, HR (95% CI)	
	Patients with previous suicidal ideation included	Patients with previous suicidal ideation excluded	Patients with previous suicide attempt included	Patients with previous suicide attempt excluded
Model 1: adjusted for matching factors <sup>a</sup>	6.43 (4.42, 9.37)	2.73 (1.35, 5.55)	9.47 (4.99, 17.98)	4.29 (1.68, 10.94)
Model 2: Model 1 + smoking status and physical activity level	6.18 (4.14, 9.22)	2.52 (1.22, 5.23)	10.73 (5.31, 21.70)	4.82 (1.74, 13.34)
Model 3: Model 2 + psychiatric disorders <sup>b</sup>	2.24 (1.32, 3.78)	0.56 (0.16, 1.98)	2.91 (1.06, 7.99)	0.41 (0.05, 3.17)

Abbreviations: BED, binge-eating disorder; HR, hazard ratio.

<sup>a</sup>Age, sex, geographic region, race, and calendar period of the cohort entry date.

<sup>b</sup>Attention-deficit/hyperactivity disorder; bipolar disorder; dysthymia; posttraumatic stress disorder; obsessive-compulsive disorder; major depressive disorder; anxiety, dissociative, or somatoform disorder; and anorexia nervosa.

total ADHD symptom level (hyperactive/impulsive versus inattentive symptoms were not independently assessed) was positively associated with suicidal behavior after adjusting for the severity of psychopathology and for comorbidities (Stickley et al., 2018). To the best of our knowledge, there are no published data describing the relationship between impulsivity and suicide risk in individuals diagnosed with BED. However, it has been reported that individuals diagnosed with BED exhibit increased levels of impulsivity compared with obese individuals not diagnosed with BED and with normal-weight individuals (Galanti et al., 2007; Hege et al., 2015; Manwaring et al., 2011; Schag et al., 2013; Ural et al., 2017). As such, it could be speculated that impulsivity is a mediating factor for suicide risk in individuals diagnosed with BED in general and that it could have contributed to the additive suicide risk observed in patients with BED having an ADHD diagnosis at baseline in this study.

To date, the relationship between bariatric surgery and suicide risk is unclear. Some studies have reported increased risk of suicidality in patients who have undergone bariatric surgery (Bhatti et al., 2016; Kontinen et al., 2019; Peterhansel et al., 2013; Tindle et al., 2010). For example, in a medical records review of individuals who had undergone bariatric surgery between 1995 and 2004, the incidence of suicide was 13.7 per 10,000 person-years in men and 5.2 per 10,000 person-years in women; this rate was higher than the reported rates of 2.4 per 10,000 person-years in men and 0.7 per 10,000 person-years in women in the general US population (Tindle et al., 2010). Similarly, a systematic review of suicide following bariatric surgery that included 28 studies reported an estimated suicide rate of 4.1 per 10,000 person-years (Peterhansel et al., 2013). Based on these findings, it could be speculated that having bariatric surgery during the baseline period had an additive effect on suicidality in patients with BED in the current study.

However, not all studies have reported that bariatric surgery is associated with increased risk of suicidality (Gordon et al., 2019; Lim et al., 2018). In a large meta-analysis (Lim et al., 2018), which included >140,000 bariatric surgery patients from 61 studies, the pooled prevalence of suicidality was 0.3%. This rate was reported to be substantially lower than the 2016 global suicide rate of 1.4% reported by the World Health Organization (2016). In another study, although 25.7% of bariatric surgery patients had a pre-surgery history of suicidality, the prevalence of self-harm/suicidal ideation was not significantly different from the pre-surgery level at 1 year or 5 years post-surgery (Gordon et al., 2019). These findings suggest that factors associated with patients who decide to undergo bariatric surgery, rather than the act of having bariatric surgery, may contribute to increased suicide risk. In support of this idea, Gordon et al. (2019) reported that most patients exhibiting suicidality after surgery were the same individuals with pre-surgery histories of suicidality.

Furthermore, consistent with observations for relative risk in this study, risk for self-harm or suicide in a Swedish population of individuals who met criteria for obesity was significantly increased in those with histories of psychiatric disorders or histories of self-harm (Kontinen et al., 2019). Unfortunately, the sample size of patients having had bariatric surgery during the baseline period in this study was too small to allow for an assessment of the impact of psychiatric disorders or history of suicidality on suicide risk in these individuals.

Studies that have examined the relationship between BMI and suicide risk have reported disparate results (Brown et al., 2018; Perera et al., 2016; Welch et al., 2016). In this study, BMI was not associated with increased suicidality risk when considered as a continuous variable, but categorical analyses indicated that obesity was associated with reduced risk compared with having a BMI in the normal range. The continuous analysis findings are supportive of data from a retrospective cohort study that reported no difference in the risk of suicide attempts in patients with BED and with versus without comorbid obesity (Welch et al., 2016). In another study, BMI and suicidality were reported to be associated in a curvilinear manner among those who did not binge eat, with low-to-intermediate BMI (<27 kg/m<sup>2</sup>) being associated with lower suicide risk than higher BMI (>27 kg/m<sup>2</sup>), and that the relationship between binge eating and suicidality was strongest in those with higher BMI (Brown et al., 2018). The results of the categorical analysis are consistent with findings from a meta-analysis that reported that being overweight or obese was associated with a significantly decreased risk for completed suicide relative to normal-weight individuals (Perera et al., 2016). This finding might be related to the reported positive association between weight suppression (i.e., the discrepancy between highest past weight and current weight) and increased risk of nonsuicidal self-injurious behavior (Keel et al., 2018). That is, the increased suicidality risk observed in individuals with BED and BMIs in the normal range relative to those in the obese range may be related in part to the presence of weight suppression.

In the current study, age was not associated with suicide risk when considered as a continuous or categorical variable. This finding is consistent with a study in adult outpatients with mental health conditions, which reported no interactions between age and suicidal ideation or suicide deaths (Rossom et al., 2017). However, having a history of suicidal ideation or of suicide attempts increased suicide risk in the current analyses. This finding is consistent with other studies that have reported that prior suicidal behavior increases risk for future suicidality (Deisenhammer et al., 2019; Schaffer et al., 2015).

The high frequency of psychiatric comorbidities among patients with BED during the baseline period is consistent with previous studies (Carano et al., 2012; Grilo et al., 2009, 2013; Guerdjikova et al., 2007; Jones-Corneille et al., 2012;

Kessler et al., 2013; Pisetsky et al., 2013; Schulz & Laessle, 2010; Welch et al., 2016). In particular, the high percentage of participants with comorbid major depressive disorder or anxiety/dissociative/somatiform disorders supports previous reports indicating that mood and anxiety disorders are among the most frequently reported psychiatric comorbidities observed in individuals diagnosed with BED (Grilo et al., 2009, 2013; Guerdjikova et al., 2007; Jones-Corneille et al., 2012; Kessler et al., 2013; Schulz & Laessle, 2010). In light of these data, it is worth noting that after adjustment for comorbid psychiatric conditions, risk of suicidality in patients with BED was not elevated relative to the general population cohort. This suggests that elevated risk of suicidality observed among patients identified as having BED could be related to the high burden of psychiatric comorbidities, which is consistent with literature that indicates that suicidality risk is increased among individuals with psychiatric disorders (Bachmann, 2018; Forrest et al., 2017; Gunnell & Frankel, 1994).

There are several limitations, many of which are common to observational database studies, to consider when interpreting these data. First, although EHR data are valuable for examining clinical healthcare outcomes and treatment patterns, the databases have the limitation of being developed for patient management and not clinical research. Therefore, is it unknown how BED was diagnosed, whether diagnostic tools were consistently applied, or the level of expertise of the healthcare providers diagnosing BED. To address this inherent limitation associated with uncertainty surrounding NLP-based analyses, two groups of individuals—those with likely BED (i.e., the BED cohort) and those with probable BED—were examined. These groups were identified using algorithms of differing stringency, which served as a type of sensitivity analysis. In this regard, the BED algorithm did not use BMI as an identification factor as it is not a diagnostic criterion for BED and could generate a false positive (e.g., patients with anorexia nervosa and not BED, patients with BED before anorexia nervosa [as was the case for one patient]). This pattern of the diagnostic crossover has been indicated in previously published literature (Schaumberg et al., 2019). Furthermore, patients who were recognized as having BED by a provider outside of the database were unlikely to be identified as having BED. To address this limitation, the study population was limited to those patients having  $\geq 1$  outpatient encounter with a healthcare provider during the 12-month baseline period who would recognize BED and who contributed notes to the database. This requirement for multiple encounters decreased the probability that a patient with BED was not identified. Second, if the analysis captured more patients with moderate or severe BED than mild BED, these results may not be generalizable to all individuals with BED. The generalizability of these data is also limited by the racial/ethnic and sex distribution, as the majority of patients

included in the analyses were white and women. Third, information was not available on some risk factors for suicide (e.g., family history, isolation, loss, aggressiveness, and impulsiveness). Therefore, the ability to assess relative suicide risk was limited and imbalances in these factors could confound the results. Fourth, the PPVs of the BED algorithms were not 100% so some of the patients included in the cohorts likely did not have BED. The PPV for the suicidal ideation algorithm was also <100%, the suicide attempt algorithm was also very low (indicating that there were false positives), and the ICD-9 coding used for determining suicidal behaviors included codes for self-inflicted harm that could be accidental rather than intentional. If these misclassifications are presumed to be nondifferential by BED status, they would have resulted in unbiased (albeit less precise) relative risk estimates. Fifth, the diagnostic codes used to assess comorbidities do not necessarily represent the presence of a condition because the code could be incorrect or associated with a condition that was later ruled out. Sixth, given the high percentage of individuals with BED experiencing psychiatric comorbidities and rare occurrence of suicide events, it is possible that an association between BED and suicidality among those without baseline suicidality was not found after adjusting for comorbidities because the analysis was underpowered. Lastly, temporality (and therefore causality) could not be determined because BED onset likely preceded its recognition. Therefore, baseline covariates may have been affected by BED onset. Temporality in terms of the timing of suicidality at baseline and BED onset was likewise unclear.

In conclusion, the prevalence and incidence of suicidal ideation and suicide attempts were greater in patients with BED than in a general population cohort. Furthermore, in patients with BED the incidence of suicidal ideation and suicide attempts was higher among patients with a history of ADHD or bariatric surgery; however, small samples for these analyses preclude the ability to draw strong conclusions based on these findings. After adjustment for psychiatric comorbidities, risk for suicidality remained increased in patients with BED who had a history of suicidality, but not among patients without a history of suicidality. This suggests that the high psychiatric comorbidity burden among patients with BED may be related to the elevated risk of suicidality in this population. As previously recommended for long-term postoperative care in patients who have had bariatric surgery (Gordon et al., 2019), clinical vigilance for suicidal ideation and intention should be high in individuals with BED regardless of weight or psychiatric comorbidities, and especially in those with comorbid ADHD.

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## CONFLICT OF INTEREST

Cynthia M. Bulik is a grant recipient and advisory board member for Shire, a consultant for Idorsia, and an author for Pearson. She received money from Shire Pharmaceuticals LLC, a member of the Takeda group of companies, for work that is not part of the current manuscript, including for activities that may include consulting, service on advisory boards, and giving speeches. Monica L. Bertoia is an employee of Optum (a UnitedHealth Group company), which was funded to conduct this study by Shire, a member of the Takeda group of companies. Mei Lu and William M. Spalding are employees of Takeda Pharmaceuticals USA and hold Takeda stock. John D. Seeger is an employee of Optum (a UnitedHealth Group company), which was funded to conduct this study by Shire, a member of the Takeda group of companies, and owns UnitedHealth Group stock and/or stock options.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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