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The effect of bariatric surgery on psychiatric course among patients with bipolar disorder

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Abstract

Objective—Bariatric surgery is the most effective therapy for severe obesity. People with bipolar disorder have increased risk of obesity, yet are sometimes considered ineligible for bariatric surgery due to their bipolar disorder diagnosis. This study aimed to determine if bariatric surgery alters the psychiatric course among stable patients with bipolar disorder.

Methods—A matched cohort study (2006–2009) with mean follow-up of 2.17 years, was conducted within Kaiser Permanente Northern California, a group practice integrated health services delivery organization that provides medical and psychiatric care to 3.3 million people. Participants were 144 severely obese patients with bipolar disorder who underwent bariatric surgery, and 1,440 control patients with bipolar disorder, matched for gender, medical center, and contemporaneous health plan membership. Controls met referral criteria for bariatric surgery. Hazard ratio for psychiatric hospitalization, and change in rate of outpatient psychiatric utilization from baseline to Years 1 and 2, were compared between groups.

Results—A total of 13 bariatric surgery patients (9.0%) and 153 unexposed to surgery (10.6%) had psychiatric hospitalization during follow-up. In multivariate Cox models adjusting for potential confounding factors, the hazard ratio of psychiatric hospitalization associated with bariatric surgery was 1.03 [95% confidence interval (CI) 0.83–1.23]. In fully saturated multivariate general linear models, change in outpatient psychiatric utilization was not significantly different for surgery patients versus controls, from baseline to Year 1 (–0.4 visits/year, 95% CI: –0.5 to 0.4) or baseline to Year 2 (0.4 visits/year, 95% CI: –0.1 to 1.0).

Conclusions—Bariatric surgery did not affect psychiatric course among stable patients with bipolar disorder. The results of this study suggest that patients with bipolar disorder who have been evaluated as stable can be considered for bariatric surgery.

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Keywords

bipolar disorder; obesity; psychiatric utilization

Bariatric surgery is the most effective treatment for severe obesity. In contrast to the modest and often temporary effect of behavioral weight loss programs (1, 2), bariatric surgery results in profound, sustained weight loss, resolution or improvement of obesity-associated comorbidities, and improved quality of life (3, 4). Loss of excess weight at two years postoperatively is between 50% and 80%, with greater weight loss achieved with malabsorptive procedures than strictly restrictive procedures (5, 6). The effects of bariatric surgery on excess weight and improvement in comorbidities persist for at least 10 years, with maintenance of 16% weight loss at 10 years postoperatively and reduced long-term mortality [hazard ratio (HR): 0.60 to 0.76] compared to usual care (7–10).

People with bipolar disorder (BD) have a prevalence of obesity up to twice that of the general population (11–15), and a life expectancy 12–25 years less than the general population, largely due to increased cardiovascular mortality (16–19). Individuals with BD also have higher risk of obesity-associated comorbidities, including type 2 diabetes, cardiovascular disease, hypertension, and dyslipidemia (20–23). The etiology of obesity in BD is multifactorial, including factors intrinsic to BD (20, 24–29) as well as medications used to treat BD, particularly atypical antipsychotics (30).

In addition to being at increased risk for obesity, patients with BD have an unmet need for obesity treatment (31) and may be denied surgical treatment due to their psychiatric diagnosis. Two surveys of bariatric surgery programs found that 2.5–5.2% of programs consider BD a definite contraindication for surgery (32, 33), and an additional 81.5% consider BD with *controlled* symptoms a possible contraindication (33). A third study reported that a substantial proportion of psychologists who evaluate bariatric candidates consider “significant psychopathology including psychosis or bipolar affective disorder” a reason to delay or deny surgery (34). The rationale for delay or denial of surgery includes beliefs that patients with BD have either poor metabolic and weight loss outcomes, or worsening of psychiatric symptoms and course after surgery (35).

To our knowledge, no study to date has examined psychiatric outcomes among patients with BD who undergo bariatric surgery. The goal of the present study was to determine if bariatric surgery affects the psychiatric course among with patient group.

Methods

Setting

The Kaiser Permanente Northern California Medical Care Program (KP) is a non-profit, group practice, integrated health services delivery organization with a membership of 3.3 million people. KP membership represents over 1/3 of the entire population in a 14-county region of Northern California. The program provides comprehensive medical services through its own facilities, including 23 hospitals, 35 outpatient clinics, 110 outpatient pharmacies, and a high-volume centralized laboratory. The sociodemographic characteristics of KP members are representative of the underlying population, except with respect to income, where the very poor and very wealthy are under-represented (36–38). The ethnic composition is commensurate with that of the US census enumerated population in the Bay Area, Metropolitan Statistical Area (MSA) (39). KP maintains comprehensive administrative and clinical electronic databases that are linked through a unique medical

record number assigned to each member at enrollment. Five-year membership retention rate is 75%.

Comprehensive mental health services are a covered benefit. Outpatient mental health care is provided in KP clinics by KP psychiatrists, psychologists, and other mental health professionals. Patients requiring psychiatric hospitalization are admitted to contract hospitals. All diagnosis and procedure codes from these hospitalizations are sent to KP and are maintained in administrative and clinical databases.

This study was approved by the Kaiser Foundation Research Institute Institutional Review Board.

Study sample

Our study cohort was selected from all 6,182 morbidly obese adult (aged 18–69 years) KP members diagnosed with BD between 2006–2009. We defined *having BD* as all those with at least one inpatient psychiatric diagnosis; at least two outpatient diagnoses by mental health clinician; or one outpatient mental health clinician diagnosis plus at least two filled prescriptions for lithium or mood stabilizers, and no seizure disorder diagnoses. We included all those who were potentially eligible for bariatric surgery. Standard National Institute of Health guidelines determine eligibility for referral to the bariatric program. These include body mass index (BMI) ≥ 40 , or BMI 35–39 with at least one obesity comorbidity requiring medical treatment (40). Patients are instructed and encouraged, but not required, to participate in a preoperative lifestyle change program. The lifestyle changes generally result in a preoperative weight loss of close to 10% of initial body weight. A few patients achieve a BMI under 35 by the date of surgery and undergo surgery as planned. Active substance abuse or psychosis are contraindications to bariatric surgery, while binge eating disorder is not. Patients who are not psychiatrically stable, as assessed by a bariatric psychologist, are not eligible for surgery. Patients with BD are evaluated for bariatric surgery based on the same criteria as patients without a BD diagnosis. Patients who had bariatric surgery prior to 2006 were excluded. Our cohort for analysis included all 144 patients with BD who underwent bariatric surgery (*exposed*, accounting for 3.3% of all bariatric surgery patients) and 1,440 matched *unexposed* patients with BD.

KP surgeons perform three primary weight loss procedures: roux-en-Y gastric bypass (RYGB), adjustable gastric banding (AGB), and sleeve gastrectomy (SG), of which RYGB accounted for the majority of procedures during the study period. KP members with a BMI ≥ 50 may request a referral for biliopancreatic diversion with duodenal switch, an operation that is performed in non-KP facilities.

Preoperative psychological screening by a bariatric psychologist is required. Both bariatric surgery and the behavioral programs are covered benefits to KP members. Postoperative psychological follow-up for issues related to bariatric surgery is provided through the primary care physician and the local department of psychiatry, as needed.

Matching

In order to constitute an appropriate comparison group to the 144 patients with BD who underwent bariatric surgery, we selected 10 unexposed for every patient with BD who was exposed to surgery. Unexposed were matched one-to-one by medical center (to control for site differences in practice patterns), gender (as gender is known to be associated with psychiatric utilization among patients with BD), and contemporaneous health plan membership (to control for temporal changes in practice patterns). To match the criteria of psychiatric stability and no active (one year prior to surgery) substance abuse or dependence

that are requirements for bariatric surgery, all controls had no active substance abuse or psychiatric hospitalization for at least one year prior to index date. For each one exposed and 10 matched unexposed, index date (i.e., baseline) was defined as the surgery date for the exposed.

For the analysis of change in outpatient psychiatric utilization, we required both exposed and unexposed to have at least nine months observation time during the 12 months prior to index date, in order to allow for calculation of baseline outpatient utilization. Two surgery patients had < 9 months' membership during the year prior to baseline and were excluded (along with their matched unexposed) from analysis.

Definitions of outcome

We employed psychiatric hospitalization as our primary measure of psychiatric course (41–43). Psychiatric hospitalization is a risk factor for suicide (43) and is an important measure of course that is assessed at clinical visits. Change in outpatient utilization was also assessed, to determine if we would observe different patterns of change over time in patients who underwent bariatric surgery.

Psychiatric hospitalization was defined as any inpatient stay at a psychiatric hospital. Outpatient psychiatric utilization was defined as any clinic visit to a psychiatry, behavioral medicine, or substance use clinic, or any visit to a primary care clinic where the provider's specialty was psychiatry, psychology, or other mental health/ behavioral medicine specialty. We included visits with a mental health provider in a primary care clinic as several KP primary care clinics have co-localization of behavioral medicine clinicians to facilitate patient access.

Covariates

Age was assessed at index date. Ethnicity was self-reported. Number of outpatient psychiatric visits and use of psychiatric medications (defined as at least two fills of a 30-day supply) were assessed during the 12 months prior to index date. Baseline BMI was defined as the most recent BMI recorded on or prior to index date. Posttraumatic stress disorder (PTSD) and medical comorbidities, including diabetes, cardiovascular disease, hypertension, dyslipidemia, and obstructive sleep apnea were assessed as clinic diagnoses or (for diabetes) inclusion in the KP Diabetes Registry (44–48) at any time prior to index date. We included PTSD as a covariate as it is associated with higher psychiatric utilization than affective disorders alone (49). We did not assess or control for psychiatric inpatient or outpatient utilization prior to the one year preceding index date, and we did not collect information on the specific diagnosis of BD [i.e., bipolar I disorder, bipolar II disorder, or BD not otherwise specified (NOS)] with which cases or controls had been diagnosed, as patients may have more different bipolar diagnoses recorded at various times in their course of disease and by different clinicians.

Analyses

Baseline characteristics of exposed and unexposed were compared using *t*-tests or chi-square tests, as appropriate.

We employed Cox proportional hazards models of time from index date to first psychiatric hospitalization after index date. The log function of *survival* (i.e., time to hospitalization) was plotted and the model's linearity assumption was not violated. We determined the HR of event-free survival associated with bariatric surgery, in an unadjusted model, and in a multivariable-adjusted model that included all putative covariates. The multivariable proportional hazards model controlled for calendar year, age, BMI, baseline outpatient

psychiatric utilization, psychiatric medication use, and comorbidities. The bootstrap method was employed to determine 95% confidence intervals (CI) around the hazard ratio (50, 51).

In an exploratory analysis, we calculated all-cause mortality for deaths occurring during follow-up. Data on cause of death was not available.

Each individual's yearly rate of outpatient psychiatric utilization (visits/year) was determined in the periods of time (one year prior to index date, 1–12 months after index date, and 13–24 months after index date). From these values, the changes in outpatient utilization from baseline (year prior to index date) to Year 1 and from baseline to Year 2 were calculated. Multivariable general linear models were employed to test the association of surgery with changes in yearly rate of psychiatric utilization, controlling for the same covariates as in the Cox models, with the exception of baseline outpatient psychiatric utilization. The bootstrap method was employed to determine 95% CIs around the estimate of effect (50, 51).

Results

Baseline characteristics for the 144 patients with BD who were exposed to bariatric surgery and the 1,440 matched (by gender, medical center, and health plan membership) unexposed patients with BD are presented in Table 1. Among exposed, the majority (86.1%) underwent laparoscopic Roux-en-Y gastric bypass. Exposed and unexposed did not differ significantly in age or ethnicity. The majority were white (72.9% cases, 67.8% controls) and female (88.9%). Mean baseline BMI did not differ (41.5, 41.6, respectively). Bariatric surgery-exposed were more likely than unexposed to be prescribed antidepressants (71.5% versus 58.0%, $p = 0.002$). Use of lithium (5.6% versus 9.7%) and first generation antipsychotics (1.4% versus 3.9%) was somewhat higher but not statistically significant among the unexposed; use of atypical antipsychotics (39.5% versus 37.6%) and mood stabilizers (40.3% versus 39.0%) did not differ significantly between groups. Bariatric surgery-exposed were less likely to have diabetes (25.0% versus 32.9%, $p = 0.05$). Prevalence of dyslipidemia, hypertension, and cardiovascular disease did not differ between groups. Obstructive sleep apnea was more prevalent among bariatric surgery-exposed than unexposed (45.8% versus 23.7%, $p < 0.001$), though this difference likely reflects ascertainment bias, as all bariatric candidates are evaluated for sleep apnea. Prevalence of diagnosed PTSD did not differ between groups. We did not collect data on other Axis I disorders.

The mean duration of observation after baseline was greater among exposed [mean 2.41 years, standard deviation (SD) = 1.25 years] than unexposed (mean 2.17 years, SD = 1.32 years), $p = 0.03$. Within our study cohort, 1,167 individuals (74.7%) were followed through the end of the observation period (12/31/2010), 367 (23.5%) dropped KP membership prior to the end of the study period, and 28 (1.8%) died. The proportion in each group did not differ by receipt of bariatric surgery.

Psychiatric hospitalization

Thirteen patients with BD who underwent bariatric surgery (9.0%) and 153 unexposed (10.6%) had at least one psychiatric hospitalization after baseline. The unadjusted survival curves are presented in Figure 1. The unadjusted HR of hospitalization associated with bariatric surgery was 0.78 (95% CI: 0.75–1.05). After adjustment for age, ethnicity, baseline psychiatric outpatient utilization, psychiatric medication use, baseline BMI, comorbidities, and calendar year, the HR for hospitalization associated with bariatric surgery was not significantly different from 1.0 (Table 2) (HR = 1.03, 95% CI: 0.83–1.23). We did not include baseline psychiatric hospitalization in our model as having no psychiatric

hospitalization in the year prior to baseline was a criterion for eligibility of bariatric surgery patients, and for selection as controls. The only variables that remained significantly associated with hazard of psychiatric hospitalization in the adjusted model were baseline outpatient psychiatric utilization (for 11 visits/year: HR = 1.62, 95% CI: 1.20–2.77), use of first generation antipsychotics (HR = 3.17, 95% CI: 1.28–3.79), and use of atypical antipsychotics (HR = 2.28, 95% CI: 1.40–2.37).

The incidence density of death was 2.88 deaths/1000 person-years of follow-up among patients who underwent bariatric surgery, and 8.96 deaths/1000 person-years of follow-up among controls. Two deaths occurred after psychiatric hospitalization, and both were among controls. Of note, these incidence densities only capture deaths that occurred while patients had health plan membership.

Change in outpatient psychiatric utilization

Compared to unexposed, bariatric surgery patients did not have significantly different changes in outpatient psychiatric utilization from baseline to Year 1 (–0.4 visits/year, 95% CI: –0.5 to 0.4) or baseline to Year 2 (0.4 visits/year, 95% CI: –0.1 to 1.0). Multivariable adjustment did not change this finding (Table 3). In the multivariable model, the difference between bariatric patients and unexposed in change in outpatient utilization from baseline to Year 1 was –0.3 visits/year (95% CI: –0.5 to 0.6) and the change from baseline to Year 2 was 0.5 visits/year (95% CI: –0.6 to 0.9). The only variable that had a borderline association with change in outpatient utilization was baseline antidepressant use, which was associated with 1.4 fewer outpatient visits at Year 1 (95% CI: –1.8 to –0.1) and 1.9 fewer visits at Year 2 (95% CI: –2.1 to 0.0).

Discussion

This is the first study to examine the effects of bariatric surgery on psychiatric course among patients with stable BD. Among 144 patients with BD who underwent bariatric surgery compared with 1,440 matched unexposed who were followed for a mean 2.41 and 2.17 years, respectively, bariatric surgery was not associated with significant differences in the risk of psychiatric hospitalization or change in rate of outpatient visits for psychiatric services. These findings were not changed when we controlled for a variety of covariates that are associated with psychiatric course, including medication use and baseline utilization. As we did not observe differences in psychiatric hospitalization between cases and controls, and psychiatric hospitalization, *prima facie*, is a marker of severe manic or depressive episode, our study demonstrates that bariatric surgery does not worsen psychiatric course among stable patients with BD.

There are several factors that might explain the change in psychiatric functioning after bariatric surgery. Extrapolation of the findings from studies of bariatric surgery among patients with unipolar depression suggests plausible mechanisms through which successful treatment of obesity would improve psychiatric course among patients with BD. Among patients with unipolar depression, weight loss is generally associated with decreased depressive symptoms and improved quality of life (52–55), though not all studies found this association (56). Weight loss after bariatric surgery might improve symptoms or disease course among patients with BD. In support of this possibility, BMI of patients with BD is associated with non-responsiveness to lithium, increased prevalence of comorbid anxiety disorders, a trend towards rapid cycling, and poorer treatment outcome (14, 57). This is a critical point for populations with BD as depressive symptoms and episodes, rather than manic episodes, dominate the longitudinal course of illness and comprise most of the illness burden (58, 59).

Alternately, bariatric surgery might increase depressive or manic symptoms due to postoperative vomiting or malabsorption of medications (60). The reported inverse relationship between severe obesity and substance use disorders in BD raises the possibility that significant weight loss may be accompanied by an increase in use of alcohol or other drugs (61, 62). Moreover, bariatric surgery is associated with increased risk of death by suicide, with an estimated rate of suicide post-bariatric surgery 4.1/10,000 person-years (10, 63, 64). Distress related to medical complications of bariatric surgery (65–70) might exacerbate psychiatric symptoms. Our finding of lower all-cause mortality among bariatric cases than controls is reassuring on this count.

There are several limitations to our findings. First, results are applicable only to patients with BD with stable psychiatric course, defined as not having had a psychiatric hospitalization in the year prior to surgery, no current substance abuse or dependence, and considered as eligible following interview by a bariatric psychologist. Patients who are psychiatrically unstable or who have ongoing substance abuse are not eligible for bariatric surgery and we cannot surmise how surgery might affect their course of disease. Second, this study did not randomize patients to surgery versus usual care. While we controlled for multiple covariates associated with the severity of disorder and utilization, it is possible that there was residual confounding due to unmeasured covariates. Third, we did not examine psychiatric hospitalization prior to the year preceding index date, as we required only one-year membership prior to index date; and we did not match groups by the frequency of diagnoses of bipolar I disorder, bipolar II disorder, or BD NOS. Fourth, the use of outpatient utilization rate as a measure of psychiatric course rests on the assumption that patients with worsening psychiatric symptoms will have more contact with their mental health clinicians (71) and that those with improvement in symptoms will have less frequent contact. It is possible that psychiatric symptoms improved or worsened after bariatric surgery, but this did not translate into changed utilization. It is also possible that an increase in psychiatric utilization might represent increased engagement in care. Finally, as we did not have data on cause of death, we were unable to ascertain whether the difference in mortality was attributable to differential rates of suicide or of cardiovascular and other medical disease. This important question remains for future study.

This study also had significant strengths. First, this is the first study to examine the effects of bariatric surgery on psychiatric course among patients with BD. Second, our study findings are generalizable to stable patients with BD who qualify for bariatric surgery. We examined a large sample of patients with BD drawn from a 3.3 million person, demographically representative health plan membership. Surgery was performed at three hospitals, which collectively operated on over 5,100 patients during the four-year study period. This large volume is a significant advantage over a single-site or tertiary care setting, where patients may not be representative of the general population of bariatric patients. Third, we leveraged electronic medical records to completely capture exposure (bariatric surgery), outcomes (inpatient and outpatient mental health utilization), and covariates. Careful consideration was given to selection of the appropriate group for comparison with patients with BD receiving bariatric surgery, and a number of important potential covariates of psychiatric course were included and adjusted for in multivariate models. Fourth, we had very low rates of loss to follow-up. Past studies of bariatric surgery outcomes have had relatively high patient attrition of up to 89% at three years (72). In our population, by comparison, cumulative loss-to-follow-up was only 23.5% at three years after index date among patients with BD. Finally, surveillance bias is not likely present, as duration of follow-up was similar between groups.

Our findings have implications for bariatric surgery teams and for mental health professionals who care for patients who are considering bariatric surgery. Patients with BD

have higher prevalence of obesity and obesity-related comorbidities such as cardiovascular disease. Medication-associated weight gain is the most commonly reported side effect among patients with BD and it contributes to lower quality of life (29). Although patients with BD are often treated with highly obesogenic medications, some bariatric surgery centers consider patients with BD ineligible for surgery due to their psychiatric diagnosis. This study provides evidence that bariatric surgery does not adversely affect psychiatric course among stable patients with BD. It suggests that people with stable BD can be evaluated for bariatric surgery using the same criteria as other patients.

Our study raises interesting questions for future study. Future study should examine weight loss outcomes among patients with BD who undergo bariatric surgery, as well as determining whether successful weight loss differentially predicts psychiatric course after surgery. Additionally, future study should examine the reasons for a lower mortality rate among patients who undergo bariatric surgery, and in particular, how bariatric surgery affects suicidal intent and suicidal behavior among patients with BD. Investigation of how bariatric surgery affects neuropsychiatric function is imperative. Among the outcomes of particular clinical relevance are cognitive function, global functioning, and severity of depressive and manic symptoms. These outcomes should be evaluated longitudinally, as they may change over time and as a function of degree of obesity. Finally, the use of bariatric surgery raises questions about how surgically achieved weight loss will affect the biosignature of BD, including structural, functional, and neurochemical measures. As the use of bariatric surgery as a treatment for severe obesity continues to grow, a complete knowledge of how this procedure affects psychiatric and metabolic course for patients with psychiatric diagnoses is needed.

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Fig. 1.
Kaplan–Meier survival curve, time from index date to psychiatric hospitalization.

Table 1

Baseline characteristics among 144 patients with bipolar disorder who underwent surgery and 1,440 matched controls

	Bariatric surgery (n = 144)	Controls (n = 1,440)	p-value
Gender , female, n (%)	128 (88.9)	1280 (88.9)	1.0
Age , years, mean (SD)	43.9 (10.4)	45.0 (12.1)	0.32
Age group , years, n (%)			0.09
18–35	38 (26.4)	341 (23.7)	
36–50	64 (44.4)	580 (40.3)	
51–60	37 (25.7)	380 (26.4)	
61–69	5 (3.5)	139 (9.7)	
Ethnicity			0.09
White	105 (72.9)	931 (67.8)	
Black	12 (8.3)	132 (7.8)	
Latino	16 (11.1)	143 (9.7)	
Multi-ethnic	6 (4.2)	118 (8.3)	
Other	5 (3.5)	116 (6.5)	
Type of bariatric procedure		–	–
Lap RYGB	124 (86.1)		
Open RYGB	5 (3.5)		
LAGB	10 (6.9)		
Gastric sleeve	5 (3.5)		
Baseline BMI , mean (SD)	41.5 (4.7)	41.6 (6.2)	0.95
Baseline BMI			0.13
< 35	7 (4.9)	104 (7.2)	
35–39	49 (34.0)	455 (31.6)	
40–44	51 (35.4)	449 (31.2)	
45	31 (21.5)	285 (19.8)	
Missing	6 (4.2)	147 (10.2)	
Psychiatric medication use , n (%)			
Antidepressants	103 (71.5)	835 (58.0)	0.002
Lithium	8 (5.6)	139 (9.7)	0.10
First generation antipsychotics	2 (1.4)	56 (3.9)	0.13
Atypical antipsychotics	57 (39.5)	543 (37.6)	0.63
Mood stabilizers	58 (40.3)	561 (39.0)	0.76
Comorbidities			
Diabetes	36 (25.0)	473 (32.9)	0.05
Dyslipidemia	84 (58.3)	827 (57.4)	0.83
Hypertension	92 (63.9)	813 (56.5)	0.09
Cardiovascular disease	11 (7.6)	153 (10.6)	0.26

	Bariatric surgery (n = 144)	Controls (n = 1,440)	p-value
Obstructive sleep apnea	66 (45.8)	341 (23.7)	< 0.0001
PTSD	18 (12.5)	247 (17.2)	0.15
Calendar year, baseline, n (%)			1.0
2006	31 (21.8)	310 (21.8)	
2007	38 (26.8)	380 (26.8)	
2008	39 (27.5)	390 (27.5)	
2009	34 (23.9)	340 (23.9)	
Baseline outpatient visits, mean (SD)	4.8 (6.1)	5.7 (10.3)	0.32
Inpatient psychiatric hospitalization after baseline, n (%)	13 (9.0)	153 (10.6)	0.55
Years of observation after baseline, mean (SD)	2.41 (1.25)	2.17 (1.32)	0.03

SD = standard deviation; RYBG = roux-en-Y gastric bypass; LAGB = laparoscopic adjustable gastric banding; BMI = body mass index; PTSD = posttraumatic stress disorder.

Table 2

Cox proportional hazards models of time from index date to psychiatric hospitalization

Variable	Multivariate model		Unadjusted	
	HR	95% CI	HR	95% CI
Bariatric surgery	1.03	0.83–1.23	0.78	0.75–1.05
Calendar year, baseline				
2006	1.00	–		
2007	0.83	0.69–1.60		
2008	0.62	0.59–1.47		
2009	0.86	0.70–1.98		
Age, years				
18–35	1.00	–		
36–50	1.27	0.68–1.36		
51–60	0.98	0.54–1.22		
61–69	1.39	0.34–1.31		
Ethnicity				
White	1.00	–		
Black	1.32	0.65–1.71		
Latino	1.63	0.95–1.99		
Multiple	1.16	0.82–1.78		
Other/missing	1.04	0.34–1.26		
Baseline BMI				
< 35	0.93	0.57–1.86		
35–39	1.00	–		
40–44	1.07	0.87–1.69		
45	0.80	0.58–1.25		
Missing	1.16	0.42–1.80		
Psychiatric medication use				
Lithium	1.29	0.68–1.62		
First-generation antipsychotic	3.17	1.28–3.79		
Second-generation antipsychotic	2.28	1.40–2.37		
Mood stabilizer	1.49	0.86–1.51		
Antidepressant	0.84	0.63–1.09		
Outpatient psychiatric visits, year prior to index date				
0–1	1.00	–		
2–5	1.02	0.95–1.92		
6–10	1.00	1.02–2.55		
11	1.62	1.20–2.77		
Comorbidities				
Diabetes	1.86	0.93–1.75		
Dyslipidemia	0.89	0.47–1.74		
Hypertension	0.92	0.73–1.33		

Variable	Multivariate model		Unadjusted	
	HR	95% CI	HR	95% CI
Cardiovascular disease	1.03	0.78–1.72		
Sleep apnea	0.82	0.49–0.95		
PTSD	1.81	1.15–2.15		

The multivariable model includes all putative covariates. HR = hazard ratio; CI = confidence interval; BMI = body mass index; PTSD = posttraumatic stress disorder.

Table 3

Differences in change in rate of outpatient psychiatric utilization (visits/year) between patients with bipolar disorder who underwent bariatric surgery and matched controls

Variable	Year 1–Year 0		Year 2–Year 0	
	Estimate	95% CI	Estimate	95% CI
Bariatric surgery	–0.3	–0.5 to 0.6	0.5	–0.6 to 0.9
Calendar year, baseline				
2006	–	–	–	–
2007	–0.8	–1.0 to 1.7	–1.0	–1.2 to 1.6
2008	–0.8	–1.4 to 1.2	–0.3	–1.2 to 1.6
2009	–1.1	–1.8 to 0.9	–0.6	–3.0 to 2.9
Age, years				
18–35	–	–	–	–
36–50	1.0	–0.8 to 1.3	1.5	–0.9 to 2.0
51–60	0.4	–1.4 to 1.0	1.1	–2.7 to 1.0
61–69	–1.2	–2.2 to 1.5	1.3	–2.4 to 1.4
Ethnicity				
White	–	–	–	–
Black	–0.4	–2.2 to 0.4	0.3	–2.5 to 1.2
Latino	–0.9	–2.1 to 0.3	–0.1	–2.5 to 1.0
Multiple	0.5	–0.9 to 2.0	0.9	–1.9 to 1.7
Other	–2.1	–2.4 to 0.4	–1.2	–3.5 to 0.3
Baseline BMI				
< 35	–0.3	–1.8 to 1.6	–1.0	–2.2 to 2.0
35–39	–	–	–	–
40–44	–1.2	–1.1 to 1.2	–0.7	–1.5 to 1.2
45	–0.1	–1.4 to 1.4	–0.7	–2.0 to 1.4
Missing	–	–	–	–
Psychiatric medication use				
Lithium	1.3	–1.9 to 1.9	1.1	–0.7 to 3.0
First-generation antipsychotic	2.4	–1.5 to 4.5	–1.1	–4.1 to 2.5
Second-generation antipsychotic	–0.4	–1.6 to 0.4	–0.4	–2.3 to 0.4
Mood stabilizer	–0.2	–1.6 to 0.1	–0.3	–1.9 to 0.5
Antidepressant	–1.4	–1.8 to –0.1	–1.9	–2.1 to 0.0
Comorbidities				
Diabetes	–0.5	–1.0 to 1.2	–0.9	–0.8 to 1.7
Dyslipidemia	0.4	–0.7 to 1.4	0.7	–1.3 to 1.4
Hypertension	0.9	–0.6 to 1.2	0.0	–1.4 to 1.2
Cardiovascular disease	–0.5	–1.3 to 1.0	–0.5	–1.3 to 1.9
Sleep apnea	–0.4	–1.4 to 0.6	–0.2	–0.7 to 2.1
PTSD	0.0	–1.8 to 1.6	–0.6	–2.4 to 1.5

Models control for all putative covariates. CI = confidence interval; BMI = body mass index; PTSD = posttraumatic stress disorder.