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Review article

# Substance use after bariatric surgery: A review

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ABSTRACT

*Background:* Prevalence of obesity has increased dramatically. Obese individuals may undergo bariatric surgery to lose excessive body fat and mitigate obesity-related comorbidities. However, bariatric patients are particularly vulnerable to substance use problems. We conducted a review to examine the prevalence change and factors associated with substance use and determine the association between substance use and health status after weight loss among bariatric patients.

*Methods:* We searched peer-reviewed articles published between January 1990 and January 2015 in several databases (PubMed, PsycINFO, Cochrane Library, Google Scholar) using different keywords combinations. Studies that focused on pre-surgery substance use only or without reported effect measurements were excluded.

*Results:* Overall, 40 studies were included in the review. Preoperative history of substance use was a reliable correlate of postoperative substance use. The prevalence of postoperative alcohol use was higher among patients with preoperative history of alcohol use than those without. Postoperative prevalence of alcohol use ranged from 7.6% to 11.8%. No significant prevalence change in cigarette smoking from pre-to postoperative period was observed. Time effect was not observed on smoking or drug use prevalence, while an increase in alcohol consumption was inconsistent across studies. The proportion of new-onset substance users among bariatric patients after surgery ranged from 34.3% to 89.5%.

*Conclusion:* Substance use is associated with poor health among bariatric patients. Preoperative assessment and postoperative follow-up should include interventions to reduce relapse among users and prevent substance use initiation.



**Contents**



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**Abbreviations**

| | |
|---|---|
| BMI | Body Mass Index |
| AUD | Alcohol use disorder |
| SUD | Substance use disorder |
| NSAID | Nonsteroidal anti-inflammatory drug |
| LAGB | Laparoscopic adjustable gastric band |
| RYGB | Roux-en-Y gastric bypass |
| VSG | Vertical sleeve gastrectomy |
| LASG | Laparoscopic sleeve gastrectomy |
| VBG | Vertical banded gastroplasty |
| WE | Wernicke encephalopathy |
| OR | Odds ratio |
| HR | Hazard ratio |
| NIDDK | The National Institute of Diabetes and Digestive and Kidney Diseases. |
| *Unit* | |
| $kg/m^2$ | BMI (*body mass index*) |
| g/l | *Blood ethanol concentration* |

## 1. Introduction

During the past decades, the prevalence of obesity has increased substantially worldwide and has become a public health concern (James, 2004). Adults aged 20 and above with body mass index (BMI) – defined as individual's body weight (kg) divided by the square of height ($m^2$) - over 30 $kg/m^2$ are considered being obese (WHO, 2000). The increases in obesity prevalence are related to dramatic lifestyle changes, including dietary habits and physical inactivity (Fryar et al., 2012). Among factors related to lifestyle changes, substance use is related to obesity since there may be overlaps in brain circuitry that underlie addictive behavior as well as overeating, and substance dependence could be reinforced by food addiction (Saules et al., 2010).

Obesity is associated with physiological and psychological comorbidities (Raj & Kumar, 2010; Anderson et al., 2007; Hayden-Wade et al., 2005). Severely obese individuals are at the highest risk of suffering obesity-related comorbidities (Freedman et al., 2007; Booth et al., 2015). Bariatric surgery is considered a good treatment option for reducing excessive body fat (Svetkey et al., 2008) because non-surgical approaches, such as lifestyle modification and pharmacologic treatment, have resulted in only modest weight loss (Fitzgerald and Baur, 2014). Individuals with BMI $\geq$40 or 35 $\leq$ BMI $\leq$39.9 with serious obesity-related comorbidities are recommended to receive bariatric surgery and individuals with BMI $\geq$30 and at least one obesity-related comorbidities might also be eligible to undertake certain type of bariatric surgery (i.e. adjustable gastric band) (NIDDK, 2015). A global survey estimates that in 2013 at least 0.01% of total population (n = 4.7 billion from 52 nations or national groupings) worldwide have undergone bariatric surgery (Angrisani et al., 2013). The successful application of bariatric surgery to treat severe obesity has been well-documented (Lawson et al., 2006). Buchwald et al. (2004) conducted a meta-analysis of adult bariatric surgery that included 136 studies covering 22 094 patients aged 16–64 years and found that, on average, 61% of excessive weight loss had been achieved for all studied patients after the surgery (excluding 30 post-operative days). Further, obesity-related medical comorbidities had been found to be resolved or improved in the majority of the patients (86% in type II diabetes, 70% in hyperlipidemia, 79% of hypertension, and 84% of apnea).

Due to physiologic changes after surgery, bariatric surgery patients were more sensitive to the effect of substance consumption than those without (Buffington et al., 2006). For instance, Ertelt et al. (2008) found that 84% of those who consumed alcohol after bariatric surgery experienced intoxicating effects of alcohol after consuming a small amount of alcohol and 29% of them indicated that the time of the intoxicating effects of alcohol lasted longer than they experienced before bariatric surgery. Additional descriptions of mechanisms for changes of substance absorption and addiction after bariatric surgery are reported elsewhere (Woodard et al., 2011; Dutta et al., 2006; Klockhoff et al., 2002). Prior studies have also documented the negative impact and risk of substance use on the health outcomes of bariatric surgery patients: some post-operative substance users may have an increased likelihood of developing Wernicke Encephalopathy (Grace et al., 1998; El-Khoury, 2010), ulcer diseases (Coblijn et al., 2014) and malnutrition (Wendling and Wudyka, 2011).

Preoperative history of substance use was prevalent and reported by up to 60% of bariatric surgery patients (Conason et al., 2013), although cessation was highly recommended for surgery candidates, preoperative substance use was significantly associated with postoperative substance use. Saules et al. (2010) found that, among 54 bariatric patients (mean age = 44.6 ± 9.1) who were enrolled in a drug and alcohol treatment program, 35.8% of them had a preoperative history of heavy use of drugs and/or alcohol. With regards to relatively high prevalence rates for alcohol, marijuana, amphetamines and tobacco use among adolescents (Winters et al., 2014; Carneiro et al., 2006), bariatric surgery patients at younger age were more likely to present substance use problems than those at older age (King et al., 2012).

Prior findings have shown that preoperative history of substance use (tobacco, alcohol, and illicit or recreational drug use) may be an important correlate of postoperative substance use (Saules et al., 2010; King et al., 2012; Raebel et al., 2014). However, it is unclear about how postoperative substance users differ from preoperative substance users in characteristics and patterns of substance use. On the other hand, the health impact of post-operative substance use on bariatric surgery patients' health conditions and weight loss outcomes are also unknown. Therefore, it is important to understand differences in postoperative substance use between 'relapsed users' (who had a substance use history but quit before the surgery to meet the requirements for undergoing bariatric surgery) and 'new-onset users' (who had never used substances before the surgery but used substances after the surgery).

We have found just three reviews (Sogg, 2007; Ertelt et al., 2008; Heinberg et al., 2012) that examined alcohol use problems

among bariatric surgery patients. Sogg summarized prior findings on alcohol use before and after bariatric surgery and stressed the dearth of research about alcohol misuse among bariatric surgery patients. Ertelt et al. provided a brief review about the prevalence change in alcohol abuse and dependence before and after bariatric surgery. Heinberg et al. discussed clinical considerations of alcohol use after surgery besides examining the prevalence change, and recommended the need to assess and manage substance use risk in order to reduce the risk of postoperative alcohol use. Overall, the existing few reviews have not well-considered the use of other types of substance after bariatric surgery except alcohol. Thus, the extent of substance use after bariatric surgery is unclear in terms of prevalence change and associated risk factors, impact on health status after weight loss, as well as factors associated with post-operative initiation of substance use. A better understanding of substance use patterns and their correlates is important for informing research directions and treatment management strategies for patients receiving the bariatric surgery. The aims of this review include to 1) determine the postoperative changes in prevalence and patterns of various substance groups (tobacco, alcohol and illicit/nonmedical drugs), 2) identify related correlates or risk factors of substance use, and 3) understand the association between substance use and health status after weight loss among bariatric surgery patients.

## 2. Material and methods

We searched research articles published between January 1990 and January 2015 using databases PubMed, PsycINFO, Cochrane Library, and Google Scholar. The search outcomes focused on substance use, including illicit or non-medical drug use, cigarette smoking or tobacco use, and alcohol use, among obese patients who underwent bariatric surgery. The keywords included "bariatric surgery OR weight loss surgery" and "substance use OR drug use OR smoking/cigarettes/tobacco use OR alcohol use". We used different combinations of keywords of drugs (including different drug classes, i.e., marijuana, cocaine, heroin, opioids, etc.) in order to locate as many articles as possible. The search was limited to peer-reviewed articles (original studies) published in English using human subjects with no limits of gender, age range, and country of study participants. Since our search was not specified with "pre-operative substance use" or "post-operative substance use", articles that only focused on substance use history before bariatric surgery were excluded. Case reports and cross-sectional studies with sample size smaller than 50 were not included in this review. Articles about medical use of prescription drugs were also excluded.

We reviewed titles, abstracts, and text thoroughly. A total of 35 articles were identified in PubMed after excluding 14 articles that focused on preoperative substance use only or had no extractable effect measurements. We also searched Google Scholar. Since Google Scholar does not have the function for setting filters to refine search results, it returned with over 22 000 articles/reports; most of them were not related to keywords. After excluding articles/reports that did not meet search criteria and repeat articles (already identified by PubMed), two additional articles were included. Databases PsycINFO and Cochrane Library were also searched; no additional articles were identified. Two more articles were identified after reviewing the *related citations* link in PubMed and reference lists of already identified articles. One additional article was identified by the reviewer. Overall, 40 articles were included in this review. Fig. 1 shows the summary of literature search.

## 3. Results

Fourteen studies of the 40 articles focused on use of a single type of substance, including *9 studies on alcohol use* (Ertelt et al., 2008; Black et al., 2003; King et al., 2012; Suzuki et al., 2012; Svensson et al., 2013; Woodard et al., 2011; Changchien et al., 2012; Klockhoff et al., 2002; Maluenda et al., 2010), *3 studies on cigarette smoking* (Grace et al., 1998; Gravante et al., 2007; Latner et al., 2004), and *2 studies on drug use* (Raebel et al., 2013, 2014). *Twenty-six studies* either examined more than one type of substance use or applied a composite score to represent use of one or more types of substance (tobacco, alcohol and/or illicit or non-medical drug use). Tables 1–4 summarize key findings of identified studies.

### 3.1. Changes in the prevalence and patterns of substance use after bariatric surgery

#### 3.1.1. Alcohol use (Tables 1 and 4)

A longitudinal study (n = 1945) (King et al., 2012) found that the current prevalence of alcohol use disorder (AUD) was higher at 2 years postoperatively than preoperative level (9.6% vs. 7.6%; $p < .01$), while no significant change was observed from preoperative to 1 year postoperatively (7.6% vs. 7.3%; $p = .98$). Another study focusing on AUD among bariatric patients (Suzuki et al., 2012) reported that the prevalence of lifetime and current AUD was 35.3% and 11.8% (mean time since surgery: 43.4 ± 6.8 months), respectively. Patients with a lifetime history of AUD and patients undergoing *Roux-en-Y gastric bypass* (RYGB) procedure were more likely to have current AUD compared to those without a lifetime AUD ($p < .05$) and those undergoing *laparoscopic adjustable gastric band* (LAGB) procedure ($p < .05$). Mitchell et al. (2015) followed 201 RYBG patients postoperatively and found that 32 patients (18.4%) developed AUD within the first 3 years of RYGB, including 13 patients (40.6%) without preoperative history of AUD, 7 patients (12.5%) who were lifetime AUD, and 12 "Recurrent AUD" (37.5%) who were AUD negative for the year before the surgery but positive for lifetime AUD before and after surgery. Of the 65 patients who had a preoperative history of AUD, 19 of them (29.2%) developed postoperative AUD, whereas only 11.9% (13/109) of whom without a preoperative history of AUD developed postoperative AUD. Conason et al. (2013) also investigated alcohol consumption following bariatric surgery using a longitudinal dataset and found that the mean frequency of alcohol use increased significantly from 1.2 at 1 month to 3.1 at 24 months postoperatively ($p < .05$), although a decrease from baseline (2.3) to 1 month was also observed ($p < .05$). Another two studies (Ertelt et al., 2008, n = 70; Black et al., 2003, n = 44) indicated that approximately 10% of bariatric surgery patients had alcohol dependence problems (Ertelt et al., 2008) and that less than 3% of them developed alcohol problems without prior history. Saules et al. (2010) conducted a case–control study among patients in a substance abuse treatment program (54 patients who underwent bariatric surgery and 54 matched cases). They found that 61.9% of bariatric patients who also reported current alcohol use behavior had preoperative history of heavy use of alcohol. There was no difference in the prevalence of alcohol dependence between bariatric patients and controls. However, compared to matched controls, alcohol-dependent bariatric patients consumed greater maximum quantity of drinks per drinking day. A similar pattern in increases of postoperative alcohol consumption was also observed by Hawke et al. (1990). The increased odds of developing alcohol problems among patients who underwent RYGB procedure as compared to those who underwent other types of bariatric surgery procedures (i.e., LAGB), were also reported in three other studies (King et al., 2012; Suzuki et al., 2012; Östlund et al., 2013). Overall, the prevalence of post-operative alcohol use was higher among patients with preoperative history of alcohol use and patients underwent RYGB surgery as compared to those without.

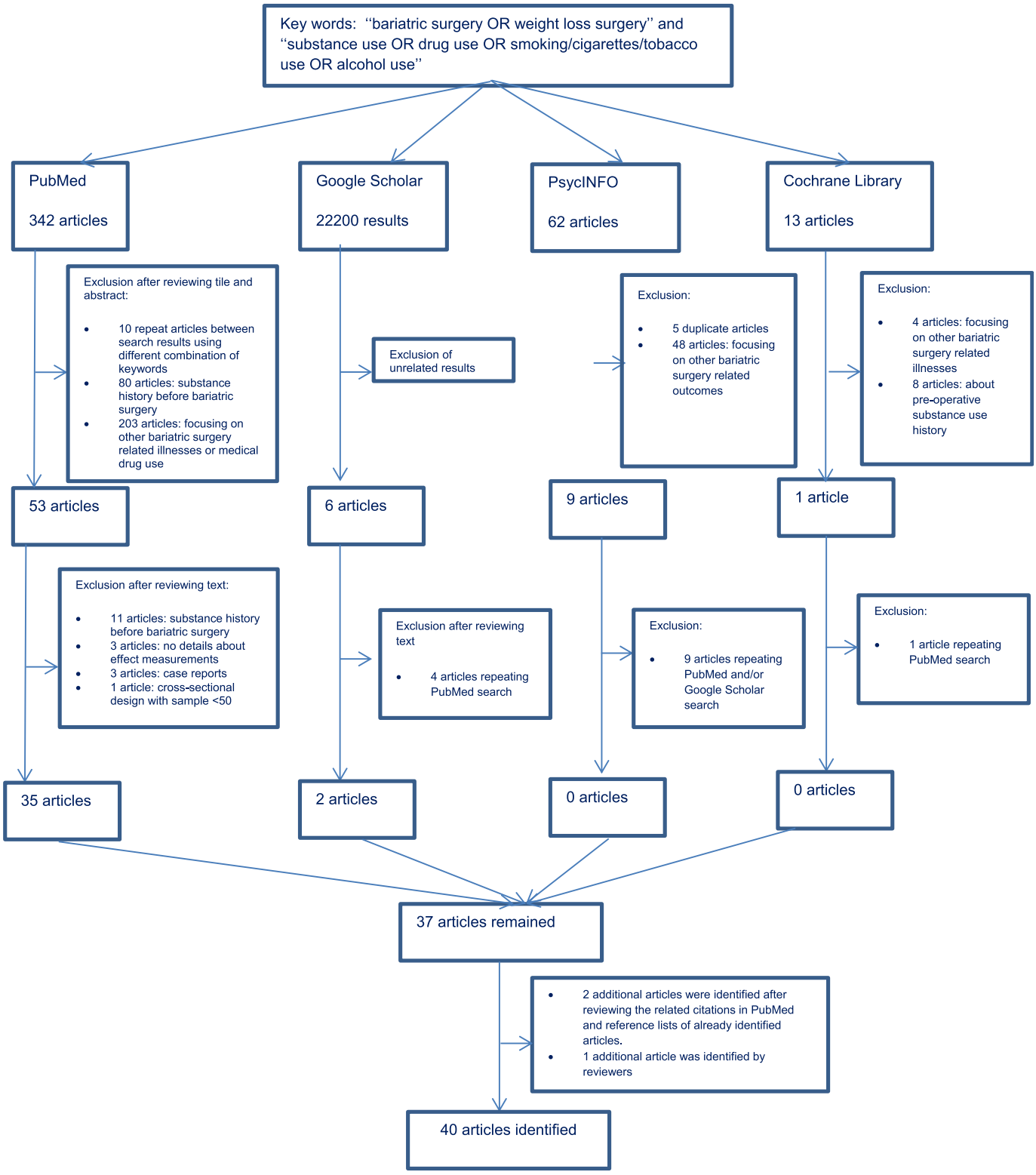


**Fig. 1.** Summary of literature search.

*3.1.2. Cigarette smoking (Tables 2 and 4)*

Grace et al. (1990) examined cigarette smoking status in a sample of 93 patients who had a vertical sleeve gastrectomy (VSG) more than 1 year postoperatively (37.6% of the patients with a preoperative smoking history). They found that 10 patients (28.6%) quit after the surgery, but 7 nonsmokers (12.1%) started smoking. Lent et al. (2013) found that older adults were more likely to reduce smoking than young adults postoperatively ($p = .002$) and that there was no significant change of smoking from pre (19.4%) to post- (14.8%) surgery, which was consistent with findings in Tae et al. (2014). However, they also found that 63.3% of 30 preoperative smokers quit after surgery and 9.6% of 125 non-smokers

**Table 1**
Studies about alcohol use after bariatric surgery (N = 9).

| Authors | Year | Design | Sample | Substance use | Selected findings |
|---|---|---|---|---|---|
| Ertelt et al. | 2008 | Cross-Sectional study | • Seventy RYBG patients, response rate = 28%<br>• Women,(85.5%), White (90.0%), mean age = 49.9 ± 9.2 yrs. | • Alcohol dependence;<br>• Alcohol abuse | • Six individuals (8.6%) were diagnosed as alcohol dependence after bariatric surgery.<br>• One individual (1.4%) qualified for a diagnosis of alcohol abuse.<br>• One individual (1.4%) had alcohol dependence remission and 2 individuals (2.9%) developed alcohol dependence after bariatric surgery |
| Black et al. | 2003 | Prospective study | • Forty-four VBG patients.<br>• Mean age = 37.7 ± 10.6 yrs. | • Alcohol dependence;<br>• Alcohol abuse | • Non-significant trend toward increased weight loss in association with alcohol abuse/dependence. |
| King et al. | 2012 | Prospective cohort study | • A total of 1945 bariatric surgery patients at 10 U S. hospitals.<br>• Female (78.8%), white (87%), median age = 47 yrs. | • AUD | • The prevalence of AUD did not significantly differ from pre-to 1 year postoperative (7.6% vs. 7.3%; p = .98), but was significantly higher at 2 years (9.6%; p < .01).<br>• Male sex, younger, smoking, regular alcohol consumption, AUD, recreational drug use, and lower 'belonging' interpersonal support preoperatively, and undergoing a RYGB were independently related to an increased odds of AUD postoperatively. |
| Suzuki et al. | 2012 | Cross-sectional study | • Fifty-one bariatric surgery patients.<br>• Female (86.3%), mean age = 51.3 ± 8.7 yrs; mean time after surgery until interview = 43.4 ± 6.8 months. | • AUD | • The prevalence of lifetime and current AUD was 35.3% and 11.8%, respectively.<br>• No associations were found between weight loss following surgery and the development of an AUD or other Axis I diagnose.<br>• Significantly more current AUD was reported in individuals with a lifetime history of AUD compared to those without a lifetime AUD (p < .05) and individuals undergoing RYGB compared to those undergoing LAGB surgery (p < .05). |
| Svensson et al. | 2013 | Prospective intervention trial | • A total of 2010 bariatric surgery patients and 2037 matched controls were recruited between 1987 and 2001.<br>• Age range: 37–60 yrs, range of follow-up time:8–22 yrs. | • Alcohol use | • During follow-up, 93.1% of the surgery patients and 96.0% of the controls reported alcohol consumption classified as low risk.<br>• Compared to controls, the gastric bypass group had increased risk of alcohol abuse diagnoses (adjHR = 4.97), alcohol consumption at least at the medium risk level (adjHR = 2.69), and alcohol problems (adjHR = 5.91).<br>• VBG increased the risk of these conditions with adjusted HRs of 2.23, 1.52, and 2.30, respectively, while banding was not different from controls. |
| Woodard et al. | 2011 | Case-crossover study | • Nineteen RYGB patients.<br>• Mean age = 44.7 ± 2.4 yrs; female (84.2%); Caucasian (47.3%) | • Alcohol use | • The peak breath alcohol content (BAC) in RYGB patients was considerably higher at 3 months (0.059%) and 6 months (0.088%) postoperatively than matched preoperative levels (0.024%).<br>• Patients took considerably more time to return to sober at 3 months (61 min) and 6 months (88 min) than preoperatively (49 min).<br>• Postoperative intoxication was associated with lower levels of diaphoresis, flushing, and hyperactivity and higher levels of dizziness, warmth, and double vision.<br>• Postoperative patients reported drinking considerably less alcohol, fewer preferred beer, and more preferred wine than before surgery. |
| Changchien et al. | 2012 | Case-crossover Trial | • Nine LAGB patients and 7 LSG patients.<br>• Mean age: 46.2 yrs (LAGB) & 47.9 yrs (LSG); Women (81.3%). | • Alcohol use | • Mean %EWL was 44.7% at 6-month.<br>• No significant changes in peak BAC or time to sober from preoperative levels (0.033%, 67.8 min, respectively) to 3 months (0.032%, 77.1 min, respectively, p < .421) or 6 months (0.035%,81.2 min, respectively, p < .198). |
| Klockhoff et al. | 2002 | Case-control study | • Twelve women who had undergone gastric bypass surgery and 12 other healthy non-operated women served as controls.<br>• Mean age = 40 yrs. | • Alcohol use | • The maximum blood ethanol concentration (Cmax) was 0.741 ± 0.211 gl/l in the operated group compared with 0.577 ± 0.112 g/l in the controls (mean diff. 0.164 g/l, 95% CI (0.021, 0.307).<br>• The median time to peak (tmax) was 10 min in the bypass patients compared with 30 min in controls (median difference-15 min (95% CI-10,-20 min).<br>• At 10 and 20 min post-dosing the BAC was higher in the bypass patients (P < .05) but not at 30 min and all later times (P > .05). |
| Maluenda et al. | 2010 | Case-crossover study | • Twelve LSG patients.<br>• Women (33.3%), mean age = 38.6 yrs. | • Alcohol use | • The maximum average peak of the Alcotest was 2.02 g/l during the postoperative period compared to 0.87 g/l during the preoperative period (p = .001).<br>• At 175 min, the blood alcohol level value reaches 0 in all pre-operatory patients.<br>• While after surgery, an average value of 0.26 g/l was observed (p = .027). After 4 h, an Alcotest average of 0.20 g/l was observed in these patients. |

Abbreviations: SUD-substance use disorder; AUD-alcohol use disorder; EWL-excessive weight loss; BMI- body mass index; WLS-weight loss surgery; SDD- Substance dependence disorder; NSAID-nonsteroidal anti-inflammatory drug; RYGB-Roux-en-Y gastric bypass; LAGB-laparoscopic adjustable gastric band; LASG or LSG-laparoscopic sleeve gastrectomy; VBG-vertical banded gastroplasty; BAC-breath alcohol content; OR-odds ratio; HR-hazard ratio; CI-confidence interval.

**Table 2**
Studies about tobacco use after bariatric surgery (N = 3).

| Authors | Year | Design | Sample | Substance use | Selected findings |
|---|---|---|---|---|---|
| Grace et al.[a] | 1990 | Prospective study | • A total of 93 patients who had a gastroplasty more than one year.<br>• Female (86%), mean follow-up time = 22.9 ± 7.8 months | • Cigarettes | • Preoperatively 38% smoked (females 36.7% males 46.2%) and 57% were heavy smokers (greater than 25 cigarettes per day).<br>• Ten smokers quitted postoperatively but 7 nonsmokers started smoking.<br>• Those who smoked before surgery lost more weight (43.26 kg) than nonsmokers (34.97 kg) and ex-smokers (32.41 kg);<br>• Those who smoked postoperatively lost more weight (44.47 kg) than nonsmokers (35.06 kg) and ex-smokers (33.07 kg); |
| Gravante et al. | 2007 | Prospective study | • Sixty LAGB patients.<br>• Mean age = 43 ± 9 yrs; female (75%) | • Cigarettes | • Postoperative infections were present in 25% (n = 15) of patients and 86.7% of these (n = 13) were superficial.<br>• All except 1 occurred in smokers (P = .0001): 47% of smokers and 3% of nonsmokers developed infections.<br>• Relative risk conferred by smoking was 14 (95%CI: 13.3–16.7). |
| Latner et al.[a] | 2004 | Case-crossover study | • Sixty-five women gastric bypass surgery patients were assessed before and after surgery.<br>• Age range:19–67, mean follow-up time = 16.4 months | • Cigarettes | • Postsurgical health behaviors (exercise and smoking) and nocturnal eating episodes were associated with weight loss.<br>• Smoking frequency tended to decrease after surgery.<br>• Significantly poorer weight loss outcomes among African Americans. |

Abbreviations: LAGB-laparoscopic adjustable gastric band; CI-confidence interval.
[a] Abstract only studies.

**Table 3**
Studies about drug use after bariatric surgery (N = 2).

| Authors | Year | Design | Sample | Substance use | Selected findings |
|---|---|---|---|---|---|
| Raebel et al. | 2013 | Retrospective cohort study | • A total of 11719 bariatric surgery patients from 10 US health care systems.<br>• Median age = 47 yrs (21 yrs and older); female (81%); white (60%), black (8%) | • Chronic opioid use before and 1 year after surgery (excluding 30 post-operative days) | • Eight percent of bariatric patients were chronic opioid users before surgery.<br>• Seventy-seven percent of pre-surgery users continued chronic opioid use in the year following surgery.<br>• Significant increase of daily morphine equivalents from pre-to postoperatively (45 mg vs. 52 mg, p < .001)<br>• Changes in morphine equivalents before vs. after surgery were not associated with % BMI loss, prior diagnosis of depression and chronic pain |
| Raebel et al. | 2014 | Retrospective cohort study | • A total of 10 643 bariatric surgery patients without preoperative history of chronic opioid use.<br>• Median age = 47 yrs (21 yrs and older); female (81.6%); white (59.2%), black (8.4%) | • Chronic opioid use in the post-surgery year(excluding 30 post-operative days) | • Four percent of patients became chronic opioid users the post-surgery year.<br>• Pre-surgery opioid total days' supply was strongly associated with chronic use post-surgery.<br>• Pre-surgery use of non-narcotic analgesics, antianxiety agents, and tobacco use were associated with increasing likelihood of postoperative chronic opioid use, while older age and banding procedure were associated with decreasing likelihood. |

Abbreviations: BMI- body mass index; RYGB-Roux-en-Y gastric bypass.

reported initiation of smoking after surgery. Similarly, Adams et al. (2012) found that 9 smokers (15.5%) who quit within 5 months prior to the surgery resumed smoking in 2 years postoperatively; nevertheless, none of never-smokers and former smokers who quit more than 5 months before surgery reported regular use of tobacco after surgery. In summary, the prevalence of smoking did not significantly change from pre-to post-surgery. Recent smokers who quit before surgery upon recommendations were likely to relapse after the surgery and approximately 10% of non-smokers started smoking postoperatively.

### 3.1.3. Drug use (Tables 3 and 4)

We reviewed drug use findings related to non-medical or illicit drug use (including abuse or dependence). Conason et al. (2013) found that the prevalence of recreational drug use did not differ from pre-to post-surgery among 155 patients (mean age: 40 ± 11 years). Saules et al. (2010) reported that, among 54 bariatric surgery patients enrolled in a substance abuse (alcohol and/or drug) treatment program, 66.7% of opiate users and 89.5% of benzodiazepine users were new-onset users. Adams et al. (2012) retrospectively reviewed medical records of 61 veterans who underwent bariatric surgery from 2001 to 2010. They found that one of the patients (1.6%) with preoperative history of drug dependence resumed use of cocaine within the two years following surgery. Raebel et al. (2013) conducted a retrospective cohort study, including 11719 bariatric patients (median age = 47 yrs) from 10 US. health care systems, and reported that 8% of bariatric patients were chronic opioid users before surgery and 77% of pre-surgery users continued chronic opioid use in the year following surgery (excluding 30 post-operative days). A significant increase of daily morphine equivalents from pre-to postoperatively (45 mg vs. 52 mg, p < .001) was observed among preoperative opioid users. Four percent of patients without prior history of chronic opioid use initiated after the surgery (Raebel et al., 2014).

### 3.1.4. Polysubstance use or substance use disorder (SUD) (Table 4)

Rather than focusing on a single substance type (alcohol use, smoking or drug use), we identified 26 articles that examined the pattern of use of multiple substances or SUD (nicotine dependence, alcohol/drug abuse or dependence) (American Psychiatric Association, 2000). Saules et al. (2010) found that among 35.8% of 54 (mean age = 44.6 ± 9.1) postoperative substance users had a history of heavy use of drugs and/or alcohol and 43.4% of them were new-onset heavy users, while 20.8% of preoperative heavy users switched to a different drug and/or alcohol after surgery than they used before surgery. Similarly, Ivezaj et al. (2014) and Wiedemann

**Table 4**
Studies about multiple types of substances use after bariatric surgery (N = 26).

| Authors | Year | Design | Sample | Substance use | Selected findings |
|---|---|---|---|---|---|
| Adams et al. | 2012 | Prospective study | • Sixty-one obese US veterans who requested bariatric surgery and met national VA eligibility requirements;<br>• Mean age = 48.3 years (range 35-60); male (60%); Caucasian (70%), African American (28%); procedures: 59% banding, 41% bypass | • Tobacco use<br>• Substance use disorders (SUD) | • Fifty-five percent of sample was former or recent smoker.<br>• None of the never smokers or former smokers used tobacco regularly in the 2 years after surgery.<br>• All 9 individuals who quit smoking in the 5 months prior to surgery resumed smoking within the 2 years after surgery.<br>• Thirteen percent of sample has history of SUD.<br>• All patients with history of SUD also had a history of tobacco use; 2 were recent smokers and also resumed smoking after surgery.<br>• One of the patients with history of drug dependence resumed use of cocaine within the 2 years following surgery.<br>• Ninety-three of tobacco users were cigarette smokers |
| Clark & Saules | 2013 | Cross-sectional study | • Sixty-seven weight loss surgery (WLS) patients.<br>• Mean age: 42.7 years (range 25-73); female (62.7%); White (86.6%); procedures: 59.7% RYGB | • Composite substance use (alcohol; cigarettes; drugs) | • Non-significant trend towards those with higher food addiction being more likely to have poorer total % weight loss outcomes (32% vs. 27%) and admit to post-WLS problematic substance use (53% vs. 39%) |
| Conason et al. | 2013 | Prospective study | • A total of 155 participants (132 women and 23 men) who underwent WLS<br>• Procedures: RYGB (n = 100) & LAGB(n = 55) | • Alcohol;<br>• Cigarettes;<br>• Drugs;<br>• Composite substance use | • The frequency of composite substance use increased significantly at 24 months (M = 1.25) relative to baseline, 1 month, 3 months, and 6 months; a "J"-shaped curve over time.<br>• Frequency of reported alcohol use decreased significantly from baseline (M = 2.29) to 1 month (M = 1.16) and from baseline to 3 months; no significant increases from baseline (M = 2.29) to 24 months<br>• Significant interaction between type of surgery and frequency of alcohol use (P = .013) over time points; frequency differs by surgery type.<br>• No significant effect of time on the frequency of recreational drug use, cigarette smoking |
| Fowler et al. | 2014 | Cross-sectional study | • A total of 154 WLS patients;<br>• White (94.2%); female (88.4%); mean age = 48.7 ± 10.8; procedures: 94.2% RYGB | • Composite MAST-AD score measuring SUD;<br>• Consumption of high glycemic index (GI) or high sugar/low-fat foods | • Participants were at significantly greater risk for new onset SUD if they endorsed a higher proportion of problematic High GI foods (OR = 1.027, p = .019) or high-sugar/low-fat foods (OR = 1.018, p = .032)<br>• Findings remained significant after controlling for other predictors of post-surgical SUD. |
| Heinberg & Ashton | 2010 | Prospective study | • A total of 413 patients who had undergone WLS.<br>• Women (75.8%), White (77.7%), mean age 47.72 years, mean BMI 50.27 kg/m$^2$ , procedures: 69%RYGB | • Composite score of tobacco, alcohol and Illicit drugs | • Forty-five (10.9%) patients had a self-reported and/or medical record-confirmed history of alcohol or substance abuse and/or dependence.<br>• Preoperative BMI being significantly greater among those with a substance abuse history than for those without history.<br>• After adjusting for the baseline BMI, the patients with a substance abuse history had a significantly greater % EWL at 6 and 9 months postoperatively, with a trend toward significance at the 12-month follow-up visit. |
| Ivezaj et al. | 2014 | Cross-sectional study | • RYGB patients (n = 143);<br>• Women (83.9 %);<br>White (94.4 %). | • Composite MAST-AD score measuring SUD (alcohol and drugs) | • A subgroup (n = 28, 19.6 %) of post-RYGB patients met criteria for probable SUD;<br>• The majority of those who met SUD criteria postsurgery (n = 19, 68 %) did not report a pre-RYGB SUD history.<br>• Family history of substance abuse, poor coping skills, and potential life stressors were related to post-RYGB SUD, particularly for the new-onset group. |

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| Reslan et al. [a] | 2014 | Cross-sectional study | • Post-RYGB patients (n = 141)<br>• At least 24 months post-surgery | • SUD | • The majority of those who met criteria for pre-RYGB SUD (n = 21, 70 %) did not continue to meet SUD criteria following RYGB.<br>• Postoperative substance misuse: 14%<br>• Those with a lower % total weight loss (%TWL) were more likely to endorse substance misuse.<br>• Family history of substance misuse was strongly associated with postoperative substance misuse.<br>• Eating-related variables were also associated with a probable postoperative SUD. |
| Pulcini et al. [a] | 2013 | Case-control study | • Twenty-six post-RYGB patients in inpatient SUD treatment with those of 26 RYGB controls without substance use history | • SUD | • Those in SUD treatment were significantly less likely to meet the surgical failure criteria of <50% EWL but evidenced greater symptoms of depression, higher rates of probable major depressive disorder and poorer quality of life. |
| Saules et al. | 2010 | Case-control study | • Out of 7199 patients receiving substance use treatment, 54 bariatric patients and 54 controls were identified.<br>• Women (70.4%); White (81.5%); mean age:44.7±9.2 yrs. | • Alcohol<br>• Cigarettes<br>• Drug use | • Cases were significantly more likely to be women and nonsmokers.<br>• Both cases and controls were equally likely to have been diagnosed with alcohol dependence;<br>• Bariatric patients (cases) were significantly more likely to also have a diagnosis of alcohol withdrawal.<br>• Relative to the matched controls, the alcohol-dependent bariatric patients reported consuming a significantly greater maximum quantity of drinks per drinking day.<br>• Most of cases sought treatment primarily for alcohol use (62.3%), with 9.4% seeking treatment for alcohol use plus another drug; 13.2% sought treatment for opiates, 7.5% for benzodiazepines, 5.7% for polysubstance abuse |
| Sockalingam et al. | 2013 | Prospective study | • A total of 363 individuals underwent a structured psychiatric interview and were classified as either surgery completers (SC) (n = 191) or surgery non-completers (SNC) (n = 172)<br>• Female (80%), mean age: 44.1±10.8 yrs. | • SUD<br>• Substance dependence disorder (SDD) | • Compared to SC group, the SNC group had significantly higher rates of overall past Axis I psychiatric disorders past anxiety disorders and past SUD (8.7 vs. 3.7 %, p<0.03), and SDD (7 vs. 1 %, p<0.005).<br>• A past history of an anxiety or SUD may play a role in patients not completing the assessment component of the bariatric surgery process. |
| Tae et al. | 2014 | Prospective study | • Thirty-two women undergoing bariatric surgery;<br>• Mean age: 41 ± 11.6 yrs. | • Tobacco<br>• Alcohol<br>• Drugs (appetite suppressants, antidepressants) | • After the surgery, there was a decrease in use of antidepressants (52% vs. 13%) and appetite suppressants (87% vs. 0%)<br>• Surgery was not a cessation factor in smoking and / or alcoholism. |
| Wiedemann et al. [a] | 2013 | Cross-sectional study | • Fifty-six post-WLS patients. | • SUD<br>• Alcohol use disorder (AUD). | • Among 56 post-WLS patients, 60% were New Onset SUD, while 40% with prior SUD history<br>• Patients with prior SUD history reported using significantly more types of substances than new onset cases and were more likely to report pre-surgical binge eating disorder<br>• Post-WLS patients are overrepresented in substance abuse treatment and are disproportionally diagnosed AUDs. |
| Yanos et al. | 2014 | Cross-sectional study | • A sample of 97 RYGB patients.<br>• Caucasian (93%), female (77%), mean age: 56.11±11.3 yrs, mean time since surgery = 8.86 yrs. | • Alcohol use<br>• Drug use | • Post-RYGB nocturnal eating, depression, and problematic alcohol use were associated with weight regain. |
| Fogger & McGuinness | 2012 | Cross-Sectional study | • A sample of 173 nurses with substance misuse in monitoring programs<br>• Twenty-five nurses who had undergone bariatric surgery (24 female) | • Composite substance use | • Of 25 nurses who had bariatric surgery, 17 nurses (68%) reported that substance abuse was a problem only after the surgery.<br>• Six nurses reported a problem with substance use before the surgery.<br>• Following the surgery participants reported they had changed substances or their substance use worsened. |

(*continued on next page*)

**Table 4** (*continued*)

| Authors | Year | Design | Sample | Substance use | Selected findings |
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| | | | | | • Five participants shared a theme that they had each known others who had developed their chemical addiction after bariatric surgery.<br>• Three reported that their response to the chemicals was different after bariatric surgery. |
| Odom et al. | 2010 | Cross-sectional study | • RYGB patients (n = 203).<br>• Female (85%), mean age = 50.6±9.8 yrs., mean follow-up after surgery = 28.1±18.9 months. | • Alcohol use<br>• Drug use | • A total of 160 of the 203 patients (79%) reported some weight regain from the nadir.<br>• Of those who reported weight regain, 30 (15%) experienced significant regain defined as an increase of ≥15% from the nadir.<br>• Significant predictors of weight regain included increased food urges, severely decreased postoperative well-being and concerns over alcohol or drug use (OR = 12.74, 95% CI 1.73–93.80, p = 0.01). |
| Östlund et al. | 2013 | Retrospective cohort study | • A total of 11 115 bariatric surgery patients.<br>• Mean age: 40.0 ±10.3 yrs.; Mean follow-up time = 8.6 years; Women (77%); procedures: gastric bypass surgery (GBS), restrictive surgery (vertical banded gastroplasty and gastric banding). | • Substance abuse<br>• Alcohol abuse | • Before surgery, there was no difference in inpatient treatment of alcohol abuse among patients who underwent gastric bypass or a restrictive procedure (incidence rate ratio, 1.1; 95% CI, 0.8-1.4).<br>• After surgery, there was a 2-fold increased risk of inpatient care for alcohol abuse among patients who had GBS compared with those who had restrictive surgery (HR, 2.3; 95% CI: 1.7-3.2). |
| Lent et al. | 2013 | Case-crossover study | • RYBG patients (n = 155)<br>• Female (80.6%),Caucasian (98.1%), mean age: 50.1±11.3 yrs. | • Alcohol use<br>• Cigarettes | • Alcohol use significantly decreased preoperatively (72.3%) to postoperatively (63.2%).<br>• As preoperative alcohol quantity rose, the odds of consuming any alcohol postoperatively increased six-fold.<br>• Older age decreased the odds of alcohol use and smoking.<br>• Smoking status did not differ pre-(19.4%) to post-(14.8%) surgery.<br>• Alcohol use and smoking were not associated with weight loss.<br>• After surgery, alcohol use declined but smoking rates did not significantly change.<br>• Younger patients are more likely to use alcohol and smoke postoperatively.<br>• Patients with a higher BMI or a history of substance use may be more likely to use alcohol postoperatively. |
| Tedesco et al. | 2013 | Prospective study | • Total 205 veterans who underwent bariatric surgery.<br>• Seventy-four (36.1%) patients with prior substance abuse history (SA group); 131 (63.9%) patients with no prior substance abuse history (NA group);<br>• Mean age = 51 yrs. (SA) & 52 yrs. (NA); female (13.5% in SA; 26.7% in NA) | • Substance abuse<br>• Alcohol use<br>• Drug abuse | • EWL% at 12 months was 71.8%, 58.0%, and 33.5% for RYGB, LASG, and LAGB, respectively, not significantly different than the NA group.<br>• Postoperative substance abuse in SA and NA patients was 8.1% and 1.5%, respectively.<br>• Eight patients developed substance abuse postoperatively; 6 patients abused alcohol, and 2 patients were using methamphetamines; 6 of the 8 patients had a prior history of substance abuse; 2 patients who had no history of abuse.<br>• More patients with a history of SA developed illicit drug or alcohol abuse after bariatric surgery compared to their NA group, although no significant difference. |
| Hawke et al. [a] | 1990 | Prospective study | • Total 240 patients who remained in the randomized trial 3 years after undergoing gastric restrictive procedure. | • Cigarettes<br>• Alcohol use | • There was a significant increase (at 3-year after surgery vs. baseline) in the number of patients smoking more than 20 cigarettes a day and a mild increase in alcohol intake. |
| Scheffel et al. | 2011 | Retrospective Cohort Study | • Total 1,908 bariatric surgery patients were followed up over 5 years. | • Alcohol<br>• Nicotine<br>• Drug use (NSAIDs) | • Of 52 patients who were found having ulcers at the gastrojejunostomy site, 39 (75%; p < 0.0001) had consumed alcohol, nicotine or NSAIDs. |

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| | | | • During follow-up period, 407 patients suffered symptoms and underwent gastroscopy. | | |
| Wilson et al. | 2006 | Retrospective Cohort Study | • Of total 1,001 RYGB patients, 226 (23%) were referred for upper endoscopy to evaluate gastrointestinal symptoms following surgery;<br>• Eighty-one of the 226 patients (36%) had marginal ulcer.<br>• Median age 43 yrs. (range 18−68); female (84%) | • Cigarettes<br>• Alcohol<br>• NSAIDs | • Factors that significantly increase the risk of marginal ulcers following surgery include smoking (AOR = 30.6, 95% CI 6.4−146) and NSAID use (AOR = 11.5, 95% CI 4.8−28). |
| Clark et al. | 2003 | Prospective study | • Eighty bariatric surgery patients who completed their 2-year follow-up.<br>• Female (78%),Caucasian (97%), mean age: 42 yrs. | • History of treatment for substance abuse (alcohol or drug abuse)<br>• Pre- or post-operative history of treatment for substance abuse is unknown. | • Patients who had received treatment for either substance abuse (n = 10) or psychiatric co-morbidity (n = 39) lost more weight compared with those without such histories (P<0.05, P<0.001, respectively). |
| Diniz et al. | 2013 | Cohort study | • A sample of 248 RYBG patients, followed up from 1 up to 12 years.<br>• Mean follow-up time = 5.1±3.1 years, mean age: 39.7±10.6 yrs.; female (75%). | • Cigarettes<br>• Alcohol use<br>• Causes of post-surgery death | • There were 9 deaths in late mortality.<br>• No association between post-surgery death and smoking.<br>• Cirrhosis represented, as well as suicide, leading cause of mortality accounting for 22.2% of total deaths. |
| Azagury et al. [a] | 2011 | Prospective study | • A total of 103 gastric bypass patients with marginal ulcers. | • Cigarettes<br>• NSAIDs | • Diabetes (OR 2.5; P = 0.03), smoking (OR 2.5; P = .02), and gastric pouch length (OR 1.2; P = .02) were significantly associated with marginal ulcer formation.<br>• The risk of developing a marginal ulcer decreased with time (OR 0.8; P < 0.01) and was not associated with the use of NSAIDs. |
| Patel et al. | 2009 | Cohort study | • A total of 2282 RYBG patients.<br>• Mean age = 41.9 yrs. (range 21−63) | • Cigarettes<br>• NSAIDs | • Of the 2282 patients, 122 (5.3%) developed marginal ulcers.<br>• Risk factors were present in 26 out of 29 patients who had received revision operation for treating ulcers (46% NSAIDs and 36% smoking).<br>• Three smokers developed recurrent ulcers postoperatively.<br>• All 3 patients who developed recurrent ulcers after revision were heavy smokers who were unwilling to quit their habit. |
| Mitchell et al. | 2014 | Prospective study | • A total of 201 RYBG patients.<br>• Median age = 48 yrs. (range 22-75); White (95.5%); male (18.9%) | • AUD<br>• SUD (non-AUD) | • Of the 201 RYBG patients, 32 (18.4%) patients developed AUD within the first 3 years of RYGB, including 13 (40.6%) “New AUD”, 7 (12.5%) “Continued AUD”, and 12 (37.5%) “Recurrent AUD”.<br>• Of the 65 patients who had a preoperative history of AUD, 19 of them (29.2%) developed postoperative AUD, compared with 11.9% (13/109) without a preoperative history of AUD<br>• Eleven percent of participants have experienced a non-AUD SUD before or after surgery.<br>• Pre-surgery non-AUD SUD: cannabis (7.5%), stimulant (3.5%), and cocaine (2.0%)<br>• Post-surgery non-AUD SUD: 1 (.5%) patient with abuse or dependence of sedatives/hypnotics/anxiolytics both before and after surgery; 1 (.5%) patient with opioid dependence after surgery only. |

Abbreviations: SUD-substance use disorder; AUD-alcohol use disorder; EWL-excessive weight loss; TWL- total weight loss; BMI- body mass index; WLS-weight loss surgery; SDD- Substance dependence disorder; NSAID-nonsteroidal anti-inflammatory drug; RYGB-Roux-en-Y gastric bypass; LAGB-laparoscopic adjustable gastric band; LASG-laparoscopic sleeve gastrectomy; OR-odds ratio; HR-hazard ratio; CI-confidence interval.

[a] Abstract only studies.

et al. (2013) reported that the percentage of new-onset SUD was 68% and 60%, respectively. Wiedemann et al. also found that patients with a preoperative SUD history tended to use more types of substances than new-onset SUD patients. In another study examining 173 nurses who underwent bariatric surgery (Fogger and McGuinness, 2012), 68% (n = 17) of them reported their problems initiated after surgery. Tedesco et al. (2013) suggested that the prevalence of postoperative substance abuse among bariatric patients with a prior history was much higher than those without the history, although the difference was not significant (8.1% vs.1.5%, p = .234), which might be related to a small sample of postoperative substance abuse group (n = 8, 6 with prior history and 2 without). Mitchell et al. (2015) found that among 201 RYBG patients who were followed for 3 years postoperatively, 11% of them had experienced a non-AUD SUD before or after surgery. Presurgery non-AUD SUD mainly included cannabis (7.5%), stimulant (3.5%), and cocaine (2.0%); only 2 patients developed postoperative non-AUD SUD (sedatives/hypnotics/anxiolytics, and opioids).

While exploring the characteristics of bariatric patients who were also in substance use treatment, Saules et al. (2010) found that nearly two out of three bariatric patients were seeking treatment primarily for alcohol use (62.3%), following by opiates (13.2%), alcohol use plus another drug (9.4%), benzodiazepines (7.5%), and polysubstance abuse (5.7%, tobacco, alcohol, or illicit/non-medical drug use). Conason et al. (2013) suggested that composite substance use (a composite score of alcohol use, recreational drug use, and cigarette smoking that assessed by a series of 10-point Likert scale items focusing on substance use) among bariatric surgery patients followed a "J"-shape curve over time after surgery. They assessed the substance use at preoperative baseline and 1, 3, 6, 12, and 24 months after surgery. The mean frequency of composite substance use at 24 months (M = 1.25) significantly increased compared to baseline (p = .019), 1, 3, 6, and 12 months (p < .002) postoperatively, although there was an immediate drop from baseline (M = 0.91) to 1 month (M = 0.42, p = .001) after surgery. The mean frequency of composite substance use did not differ by surgery type. Overall, the available data suggested that there was an increased trend in substance use after bariatric surgery and over half of postoperative substance users were new-onset users without preoperative history.

### 3.2. Factors associated with initiating substance use after surgery

Multiple psychological and physiological factors are related to the change in substance use (tobacco, alcohol, or illicit or non-medical drug use) after bariatric surgery. Pulcini et al. (2013) compared 26 bariatric patients who were in SUD treatment and 26 control patients without postoperative SUD problem. They found that SUD treatment group displayed greater symptoms of depression, a higher prevalence of probable major depressive disorder and poorer quality of life compared to the control group. Likewise, Ivezaj et al. (2014) reported that patients with family history of substance abuse (drugs or alcohol, p < .05), poor coping skills (p < .01), and potential life stressors (p < .05) had increased odds of developing postoperative SUD. In addition to family history of substance use, Reslan et al. (2014) identified that eating behavior related factors (preoperative food addiction, postoperative nocturnal eating, subjective hunger, and environmental responsiveness) were associated with postoperative substance use. Further, patients with higher percentage of problematic high glycemic index foods (OR = 1.03, p = .019) or high-sugar/low-fat foods (OR = 1.03, p = .032) were at high risk of new-onset substance use (Fowler et al., 2014). King et al. (2012) also identified factors that might increase the odd of postoperative AUD, including 'male sex, younger, smoking, regular alcohol consumption, recreational drug use, lower 'belonging' interpersonal support preoperatively, and undergoing a RYGB'. Svensson et al. (2013) conducted a prospective intervention trial (2010 bariatric patients and 2037 matched non-operative controls) to identify potential effect of various surgical procedures on developing substance use problems. They found that, compared to controls, RYGB group and VBG group had the increased odds of having alcohol abuse (HR: 4.97 and 2.23), and alcohol problems (HR: 5.91 and 2.30). Raebel et al. (2014) suggested that preoperative use of non-narcotic analgesics, antianxiety agents, and tobacco use were associated with an increased likelihood of postoperative chronic opioid use, while older age and banding procedure were associated with a decreased likelihood. In summary, initiation of substance use after bariatric surgery was associated with psychological problems and stress, addiction transfer/substitution, mechanism change of substance absorption, and family history and prior history of substance use, as well as presurgery eating habits.

### 3.3. Postoperative substance use and weight loss

A few studies explored the association between pre/postoperative substance use (tobacco, alcohol, or illicit or non-medical drug use) and weight loss after bariatric surgery. Heinberg and Ashton (2010) (n = 413) found that the percentage of excessive weight loss (% EWL) among patients with preoperative history of substance use (tobacco, alcohol, or illicit drug use) was significantly higher than patients without the history. This favorable effect of substance use on weight loss was also reported by Grace et al. (1990) (n = 93), Pulcini et al. (2013) (n = 52) and Clark et al. (2003) (n = 80). Grace et al. reported that postoperative smokers lost most weight compared to non-smokers and ex-smokers (44.47 kg vs. 35.06 kg vs. 33.07 kg). Pulcini et al. found that, although patients who were in SUD treatment group were more likely to lose more than 50% of excessive weight than those not in the SUD treatment group, they were at higher risks of mental problems, such as depression. Clark et al. (2003) also suggested patients who received treatment for substance abuse or psychiatric co-morbidity lost more weight than those not received treatment (p < .01). Reslan et al. (2014) examined the relationship between weight loss and substance use in a backward pathway (n = 141). They found that patients with a lower percent total weight loss (% TWL) were more likely to develop substance misuse after surgery. A cross-sectional study (Odom et al., 2010) reported that 79% of 203 bariatric surgery patients had experienced various levels of weight regain from the nadir weight after surgery, and a 12-fold risk (OR) of regaining weight was suggested to be due to alcohol or drug use problems. Yanos et al. (2014) identified that postoperative nocturnal eating, depression, and problematic alcohol use were main correlates of weight regain. In summary, available data suggested that substance use may have favorable effect on weight loss, although higher risk of mental problems may present simultaneously, however, postoperative substance use was also potentially associated with weight regain among bariatric surgery patients.

### 3.4. Postoperative substance use and health status after weight loss

We identified 12 studies that examined potential health impacts of substance use on bariatric surgery patients. Findings suggested that postoperative substance use was associated with worse health status.

#### 3.4.1. Alcohol use

Alcoholic cirrhosis was one of the leading causes of mortality among bariatric surgery patients, and Diniz et al. (2013) reported that 2 of total 9 deaths (22.2%) after surgery were caused by

alcoholic cirrhosis. Bariatric surgery procedures may alter the alcohol pharmacokinetics and mechanism. Postoperative patients displayed higher peak alcohol concentration, faster absorption and extended time of returning to sober (Klockhoff et al., 2002; Maluenda et al., 2010; Woodard et al., 2010; Changchien et al., 2012). Wernicke Encephalopathy (WE) was a severe complication of postoperative alcoholism and malnutrition. It could result in ophthalmoplegia, confusion, memory deficit, nystagmus, gait ataxia and death (Reuler et al., 1985; Grace et al., 1998).

*3.4.2. Cigarette smoking*

Cigarette smoking may increase the risk of developing ulcers postoperatively. Patel et al. (2009) conducted a retrospective review of medical records for 2282 RYGB patients from 1984 to 2006. Among 122 patients who developed marginal ulcers, smoking and drug use was present in 81% of the 39 patients who underwent revisional surgery for intractability rather than successfully treated with drugs, and 36% of them were regular smokers. Three patients who developed recurrent ulcers postoperatively were all heavy smokers and not unwilling to quit. A similar study (Azagury et al., 2011), which retrospectively reviewed data of 103 patients with marginal ulcers, found that smokers were 2.5 times more likely to develop marginal ulcers than non-smokers ($p = .02$). Wilson et al. (2006) studied a sample of 81 patients who developed marginal ulcers following surgery and found that smoking increased the risk of marginal ulcers (Adjusted OR = 30.6, 95% CI: 6.4–146). The large ORs and wide confidence intervals were interpreted due to a small sample size of the subgroup. In addition to marginal ulcers, Gravante et al. (2007) suggested that smoking was related to postoperative wound infections. The prevalence of wound infections among smokers was higher than that among non-smokers (47% vs. 3%, $p = .0001$). A relative risk value of 14 that conferred by smoking was also reported (95% CI: 13.3–16.7).

*3.4.3. Drug use*

The potential health impact of illicit drug use after bariatric surgery has not been discussed in identified literatures. However, several studies have indicated the potential influence of nonsteroidal anti-inflammatory drugs (NSAIDs), after bariatric surgery on marginal ulcers formation. Scheffel et al. (2011) identified 54 marginal ulcer patients who underwent bariatric surgery from 2006 to 2010 and they found that 75% of the 54 patients ($p < .0001$) had consumed NSAIDs, alcohol, or nicotine. Wilson et al. (2006) suggested that NSAID use increased the risk of marginal ulcers following surgery (Adjusted OR = 11.5, 95% CI: 4.8–28).

## 4. Discussion

This is the first review of substance use prevalence and correlates that covers tobacco, alcohol, and illicit/nonmedical drug use (including SUDs) among bariatric surgery patients. The reported prevalence of postoperative alcohol use among bariatric surgery patients ranged from 7.6% to 11.8%. Studies of postoperative alcohol use by surgical procedures suggested that undergoing a RYGB surgery was associated with increased odds of having alcohol use problems after surgery comparing to undergoing other types of bariatric surgery procedures. This pattern might be explained by the altered alcohol metabolism after gastric bypass (Ertelt et al., 2008). No significant change in the prevalence of smoking from pre-to post surgery was observed, although a non-significant decrease in cigarettes smoking prevalence from pre- (19.2%) to postoperative (14.9%) period was reported (Lent et al., 2013). However, use of other tobacco products was frequently not specified in the studies reviewed except for Adams et al. (2012). Smoking is a risk factor of developing marginal ulcers among bariatric patients (Patel et al., 2009). Approximately one third of patients who underwent revisional surgery to treat marginal ulcers after surgery were regular smokers (Patel et al., 2009; Azagury et al., 2011; Wilson et al., 2006). A "J"-shape curve trajectory of composite substance use scores over time after surgery was proposed (Conason et al., 2013), indicating an immediate decline from baseline (pre-surgery) to 1 month after surgery and then a significant increase after 1 month postoperatively. The time-related pattern was not observed on cigarette smoking or recreational drug use, while an increase in alcohol use prevalence was not consistent across studies (King et al., 2012; Tae et al., 2014).

Our review indicated that preoperative history of substance use was a reliable correlate of postoperative substance use. The proportion of new-onset substance users among bariatric patients after surgery ranged from 34.3% to 89.5%. Among adults with no prior use history, certain types of drugs (opiate, benzodiazepine) were more likely to be initiated after surgery compared to alcohol and cigarettes (Saules et al., 2010). Relapsed users tended to use more types of substances (including initiating use of a different substance) than new-onset users (Wiedemann et al., 2013). Potential risk of resuming drug use after surgery existed in patients who quit before surgery (Adams et al., 2012). Preoperative chronic opioid users might increase the dose of opioids for pain management, which may be related to an increased in pain sensitivity, a decrease in pain detection thresholds among obese individuals and altered pain processing after bariatric surgery (Raebel et al., 2013; Dodet et al., 2013). However, the increase in access to and use of opioids may raise the likelihood of opioid-related adverse events (i.e. tolerance or overdose). Adults in some occupations might be vulnerable to developing substance use problems, such as nurses, who have high levels of job stressors and access to substances at work (Fogger and McGuinness, 2012). Veterans are also at high risk of postoperative substance use due to their high prevalence of psychological and psychiatric problems (Adams et al., 2012; Tedesco et al., 2013).

Further, the mechanisms underlying the change of substance absorption may fasten the onset of substance-related pharmacological effects on bariatric surgery patients, and increase substance-related adverse events. Higher maximum blood ethanol concentration, faster speed of absorption of ethanol, longer time to return to sober were observed among bariatric surgery patients, comparing with controls without history of bariatric surgery (Klockhoff et al., 2002; Maluenda et al., 2010; Woodard et al., 2011). Additionally, postoperative weight loss may be related to opportunities of substance use. For example, Changchien et al. (2012) suggested that some obese patients might become more confident and socially active after losing a substantial proportion of weight, leading to greater alcohol use opportunities and alcohol use. Thus, given a high proportion of patients with prior history of alcohol use and an elevated mortality rate of bariatric surgery patients due to alcoholic cirrhosis (Diniz et al., 2013), patients, especially alcohol users, should be well-informed about an increased health risk associated with postoperative alcohol use before undergoing the surgery. Although smoking could increase weight loss in short term due to the appetite suppressing effect of nicotine (Adams et al., 2012), education about smoking health risk as well as cessation interventions should be provided to all patients before and after the surgery.

Substance use after bariatric surgery is associated with postoperative medical complications and psychological problems. Presurgery assessment and education for bariatric surgery candidates should include educational information about potential medical complications that could be triggered or enhanced by postoperative substance use. Patients' education should incorporate prevention materials of substance use to reduce relapse among

substance users and to prevent substance use initiation among never-users of substance after surgery. For example, Ashton et al. (2013) conducted a pilot intervention study in a group of 86 patients with a history of substance abuse or at-risk substance use applying for bariatric surgery (mean age = 46.2 years). The 90-min group intervention consisted of "psycho-education" and "discussion about the effects of substances and addictions after surgery". The post-intervention evaluation revealed a significant increase in knowledge regarding negative effects of postoperative substance abuse as well as healthy alternative coping strategies. As motivated by health reasons, patients also reported a lower intention of drinking alcohol after surgery and an increase in abstaining from alcohol use. On the other hand, inconsistent or unspecific follow-up healthcare services (e.g., resuming care with a health care provider unfamiliar with bariatric surgery) may put patients at risk for inappropriate treatment or medication use, leading to adverse health conditions (Sasse et al., 2008). Incorporating post-surgery psychological services to regular follow-up visits (e.g., rescreening for substance abuse, checking weights at each follow-up visit) may reduce postoperative substance abuse (Tedesco et al., 2013).

The findings of this review should be interpreted within the context of several limitations. Small sample size is the main limitation of most studies reviewed, because samples of these studies were often based on existing patient databases, such as substance abuse treatment programs or bariatric surgery registry databases. Due to a low prevalence of bariatric surgery among patients in substance abuse treatment programs or a low response rate of collecting substance use related information from previous bariatric surgery patients (Ertelt et al., 2008), the available sample size was often small. Study findings from a small sample size are limited in generalizability, and they should be interpreted with cautions. In addition, limited prospective studies were identified so that the causal and temporary relationship between postoperative substance use and patients' health and/or weight outcomes after bariatric surgery was inconclusive. In the meantime, very few studies have taken into account patients' demographic characteristics (i.e., gender, race/ethnicity) in the analysis of substance use after bariatric surgery, which might limit the interpreting perspectives of varying levels of substance use among bariatric surgery patients. Of the identified studies, only one study (Latner et al., 2004) mentioned that African Americans had poorer weight loss outcome. Another study suggested that alcohol use among bariatric surgery patients differed by gender and age, and male and younger group were at elevated risk (King et al., 2012). In addition, reported rates of new-onset substance users could be over-estimated due to information bias since self-reported history of preoperative substance use could be under-reported and patients who denied their history of substance use prior to undergoing bariatric surgery might be misclassified as new-onset substance users. At last, very few studies have examined illicit drug use and its prevalence change after bariatric surgery, and the types of tobacco use are often not specified to allow reviewing postoperative health conditions by the pattern and frequency of tobacco use. Taken together, future studies including a larger sample or using a longitudinal design are needed to better understand the complex relationship between pre-and postoperative substance use and to elucidate various psychological and medical factors for relapsed users and new-onset users, including trajectories of postoperative substance use over time.

## 5. Conclusion

This review suggests that healthcare providers should assess bariatric surgery patients' substance use (tobacco, alcohol, and illicit or non-medical drug use) status and risk, especially individuals with a history of substance use or mental health problems, in order to address their unique needs for prevention and to improve healthcare plans for post-surgery follow-up services. Given a rise in the prevalence of obesity (Fryar et al., 2012) and increasing prevalence of severe obesity among children and adolescents (Li et al., 2016), the number of bariatric surgery patients is expected to grow over time. There is a need to increase research efforts to elucidate the prevalence and risk factors of substance use or SUDs in this medically vulnerable group.

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## Contributors

Author Li conceived the research question, conducted the literature search and drafted the manuscript. Author Wu helped with conceptualization of the research question, and critically reviewed, edited and revised the manuscript.

## Conflicts of interest

Authors declare they have no conflicts of interest.

All authors have read and approved this manuscript, which has not been previously published and is not under consideration for publication elsewhere. All applicable subject protection guidelines and regulations were followed in the conduct of the research. Both authors contributed in the writing of this manuscript. Author Li conceived the research question, conducted the literature search and drafted the manuscript. Author Wu provided guidance on the conceptualization of the research question, and critically reviewed, edited and revised the manuscript.

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