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Health Disparities in Adolescent Bariatric Surgery: Nationwide Outcomes and Utilization

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Abstract

Purpose—Bariatric surgery represents an appropriate treatment for adolescent severe obesity but its utilization remains low in this patient population. We studied the impact of race and sex on preoperative characteristics, outcomes, and utilization of adolescent bariatric surgery.

Methods—Retrospective analysis (2007-2014) of adolescent bariatric surgery using the Bariatric Outcomes Longitudinal Database, a national database that collects bariatric surgical care data. We assessed the relationships between baseline characteristics and outcomes (weight loss and remission of obesity-related conditions (ORCs)). Using the National Health and Nutrition Examination Survey and US census data, we calculated the ratio of severe obesity and bariatric procedures among races and determined the ratio of ratios to assess for disparities.

Results—1,539 adolescents underwent bariatric surgery. Males had higher preoperative BMI (51.8 ± 10.5 vs 47.1 ± 8.7), $p < 0.001$) and higher rates of obstructive sleep apnea (OSA) and dyslipidemia. Blacks had higher preoperative BMI (52.4 ± 10.6 vs 47.3 ± 8.3 ; 48.7 ± 8.8 ; 48.2 ± 12.1 kg/m², Whites, Hispanics, and Others, respectively $p < 0.001$) and higher rates of hypertension, OSA, and asthma. Weight loss and ORCs remission rates did not differ between sexes or races. After accounting for the rate of severe obesity in each racial group. White adolescents underwent bariatric surgery at a higher proportion than Blacks and Hispanics (2.5 and 2.3 times higher, respectively).

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Conclusions—Preoperative characteristics vary according to race and sex. Race and sex do not impact twelve-month weight loss or ORC's remission rates. Minority adolescents undergo bariatric surgery at lower-than-expected rates.

Keywords

health disparities; health inequalities; adolescent obesity; pediatric obesity; bariatric surgery; gastric bypass; sleeve gastrectomy

Despite substantial efforts to prevent and treat childhood obesity, pediatric obesity rates continue to rise with more notable increases in the prevalence of severe obesity in adolescents.¹ Examination of the National Health and Nutrition Examination Survey (NHANES) demonstrated that 33% of children met criteria for being overweight, including 9% meeting criteria for severe obesity, defined as age- and sex-specific body mass index (BMI) $\geq 120\%$ of the 95th percentile, or BMI ≥ 35 kg/m².^{1,2} This represents approximately 4.5 million children and adolescents with severe obesity in the United States (US) that require intensive obesity treatment.³

Obesity in childhood and adolescence is associated with serious obesity-related conditions (ORCs), such as type 2 diabetes mellitus, hypertension, obstructive sleep apnea (OSA), gastroesophageal reflux disease (GERD), cholelithiasis, nonalcoholic fatty liver disease, dyslipidemia, pseudotumor cerebri, and musculoskeletal pathologies.^{4,5} Obese children are likely to carry obesity to adulthood and to have increased morbidity and mortality risk.^{6,7} Specifically, Freedman et al. demonstrated that 88% of adolescents with a BMI $\geq 99^{\text{th}}$ percentile develop adult obesity, suggesting the need for more aggressive treatment in this subgroup of patients.⁸

Bariatric surgery is a treatment option for adolescents with severe obesity who have failed to lose weight after 6 months of behavioral and medical interventions.⁹ It has been performed since the 1980's, gaining widespread utilization in the early 2000s.¹⁰ In 2004, a panel of experts recommended bariatric surgery for adolescents with BMI ≥ 40 kg/m² and ORCs, or BMI ≥ 50 kg/m² regardless of ORCs.⁹ Concerns for worsened outcomes due to strict BMI requirements and growing evidence regarding the safety and efficacy of bariatric surgery led to modification of the qualifying criteria.^{11,12} Currently, adolescents with BMI ≥ 35 kg/m² and major comorbidities, or BMI ≥ 40 kg/m² with minor comorbidities are candidates for bariatric surgery.¹³

The rates of bariatric surgery utilization in adolescents has plateaued since 2003 and still remains low despite the increasing rates of adolescent obesity and increased prevalence of ORCs over the same period of time.¹⁴ Patient-, provider-, and system-level factors may be associated with this trend. Notably, insurance coverage and the authorization process is more complex in adolescents than in adults; insurance coverage is not easily predictable even for patients meeting all the defined criteria. Inge et al. reported that less than half of adolescents received approval for bariatric surgery on the first request.¹⁵

Racial disparities in childhood obesity have been recognized extensively. In 2013-2014, the obesity rate in White children was 16%, compared to 19% in Blacks and 22% in

Hispanics.¹⁶ In this study, we analyzed the impact of race on the preoperative characteristics and postoperative outcomes of bariatric surgery in adolescents. Further, we studied whether the utilization rate of bariatric surgery is lower in non-White adolescents despite the higher prevalence of obesity in minority groups.

Methods

Participants and Materials

Adolescents with age 12 to <19 years who underwent bariatric surgery were identified using the Bariatric Outcomes Longitudinal Database (BOLD), years 2007-2014. The BOLD, created by the Surgical Review Corporation (SRC), is a repository from the American Society for Metabolic and Bariatric Surgery– Bariatric Surgery Center of Excellence (BSCOE) participants.¹⁷ BSCOE participants (563 centers, during the study period, distributed across the nation) entered prospective data for bariatric surgery patients during all phases of care. Each patient was followed over time, including preoperative visits, hospital stay and postoperative visits.¹⁷ Verification of the data occurs through site inspections and data reconciliation.¹⁷ With SRC's approval, the data from subjects who agreed to allow their information to be used for research can be deidentified and used for aggregate data analysis.

Demographic characteristics included age, sex, and race (as classified by the BOLD; the racial group 'Others' included Asians, Native Americans, and Pacific Islanders). Baseline clinical characteristics included preoperative BMI (lowest BMI prior to surgery), and ORCs. The primary outcome was weight loss, measured by absolute changes (BMI units and net weight loss in kilograms) and relative changes (percent of total weight loss (%TWL)). Secondary outcomes were the remission rate of ORCs, calculated as the proportion of subjects whose preoperatively identified ORCs resolved after surgery.

The NHANES database and US census population data from the years 2013-2014 were used to calculate the estimated number of adolescents with severe obesity, stratified by sex and race. The NHANES is a continuous survey that uses a stratified, multistage, clustered probability sample design to acquire a representative sample of the US population. More information about its methodology can be found on the NHANES website (<http://www.cdc.gov/nchs/nhanes/>). Deidentified data was used for this study and it was exempt from Institutional Review Board approval by the University of Texas Medical Branch.

Obesity-Related Conditions

ORC's included hypertension, diabetes, OSA, GERD, asthma, hyperlipidemia, and depression. ORC's were defined as follows. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 100 mmHg at two separate clinical evaluations or high blood pressure controlled with the use of antihypertensive medications. Diabetes was defined as fasting blood glucose >125 mg/dl or pre-existing diagnosis of diabetes mellitus treated with diabetes medications and/or insulin. OSA was defined as the presence of sleep apnea symptoms and a diagnosis confirmed by sleep study (regardless of use of continuous positive airway pressure (CPAP) therapy). GERD was defined as intermittent or chronic symptoms of reflux requiring treatment (proton pump

inhibitors (PPI) or H2 blockers). Asthma was defined as intermittent or variable symptoms of asthma requiring pharmacologic treatment. Hyperlipidemia was defined as elevated levels of triglycerides and/or total cholesterol.

Subjects identified to have ORC's preoperatively were assessed for remission 12 months after surgery. We defined remission of ORC's as follows. Remission of hypertension was defined as measurements of SBP <120 mmHg and DBP <80mmHg without antihypertensive medications. Remission of diabetes was defined by fasting blood glucose < 100 mg/dl without the use of diabetes medications or insulin. Remission of OSA was defined as the absence of sleep apnea symptoms and no requirement of CPAP therapy. Remission of GERD was defined by the resolution of reflux symptoms without PPI or H2 blockers. Remission of asthma was defined as the absence of symptoms and no requirement of pharmacologic treatment. Remission of hyperlipidemia was defined by the normalization of triglycerides and total cholesterol levels.

Statistical Methods

Variables were described with means (standard deviation) or frequency and proportion, for continuous and discrete variables, respectively. Bivariate analyses included t-tests, ANOVA, Fisher's exact, and chi-squared tests, as appropriate to assess the relationships between variables and to assess changes in these variables at 12-month after surgery.

We examined the impact of race, gender, and surgery type on rates of remission of each ORC by 12 months postoperatively. The difference in this rate was compared using Fisher's exact/chi-squared tests. Finally, within each surgery type, we examined how race impacted 12-month change in BMI with a linear model. Post-hoc Tukey's test was used to identify differences between means (after and before surgery). Only subjects with available data at least 12 months after surgery were included in the postoperative outcomes analysis.

Estimates of obesity rates from the NHANES and US census population data were used to calculate the number of adolescents with severe obesity, stratified by race and sex. We calculated the ratio of number of severe obesity cases in each race to the number of severe obesity cases in Whites. Next, using BOLD data, the ratio of the observed number of bariatric surgeries in each race to the observed number of bariatric surgeries in Whites was calculated. Lastly, we determined the ratio of ratios (ROR) (the ratio of the number of severe obesity cases in each race as compared to Whites, divided by the ratio of the observed number of bariatric surgeries in each race as compared to Whites). In the absence of a racial disparity, we would expect the ROR to be one, i.e., the ratio of surgeries in each race relative to Whites should be similar to the ratio of severe obesity cases in each race relative to severe obesity cases in Whites. In addition, we calculated the expected number of cases in each minority group using the observed rate of bariatric surgery in Whites and accounting for race- and sex-specific severe obesity rates.

Results

Baseline characteristics

We identified 1,539 adolescents who underwent bariatric surgery. Table 1 shows demographic characteristics, preoperative BMI, rates of ORCs, and the proportion of each type of bariatric procedure. Our sample demonstrated a greater proportion of females (76%; $n=1176$) and Whites (63%; $n=962$) undergoing bariatric surgery. The average age at surgery was 16.9 ± 2.6 years and the average preoperative BMI was 48.2 ± 9.4 kg/m². The most common ORC was hypertension (57%; $n=821$). Gastric bypass (GB) was the most commonly performed procedure (43%; $n=656$), followed by gastric banding (AGB) (39%; $n=600$).

Table 2 shows the comparison of baseline characteristics. Males had higher preoperative BMIs than females (51.8 ± 10.5 vs. 47.1 ± 8.7 ; $p<0.001$), and were more likely to have OSA (31 vs. 22%; $p<0.001$), and dyslipidemia (17 vs. 12%; $p=0.04$). Females were more likely to report depression symptoms (25 vs. 17%; $p<0.001$). Blacks had higher preoperative BMIs (52.4 ± 10.6 kg/m²) compared to other races (52.4 ± 10.6 vs 47.3 ± 8.3 ; 48.7 ± 8.8 ; 48.2 ± 12.1 kg/m²; Whites, Hispanics, and Others, respectively), and were more likely to have hypertension (65%; $p<0.001$), OSA (35%; $p<0.001$) and asthma symptoms (25%; $p=0.04$) when compared to other racial groups. Symptoms of depression (27%; $p<0.001$) and GERD (27%; $p=0.001$) were more common in Whites.

GB was the most commonly performed bariatric procedure in Blacks and Hispanics (56 and 50%, respectively) whereas AGB was the most common procedure in Whites (43%) ($p<0.001$) (Table 2). Adolescents who underwent GB presented with higher BMIs (50.4 ± 9.1 kg/m²) vs. 45.7 ± 7.3 ; 48.4 ± 10.8 ; 44.1 ± 9.9 kg/m²; AGB, sleeve gastrectomy (SG) and other procedures, respectively; $p<0.001$). Furthermore, hypertension (45%; $p=0.01$), GERD (49%; $p=0.02$), and asthma symptoms (48%; $p=0.01$) were more commonly observed in subjects undergoing GB (Table 2). Demographic and clinical characteristics of the subgroup of patients with available data at least 12 months after surgery were similar to that of the entire cohort (eTable 1-2).

During the years 2007, 2008, and 2010, GB was the most frequently utilized procedure (63, 48 and 43%, respectively). AGB was the most common procedure in 2009 and 2011 (47 and 40%, respectively). SG was the most common procedure from 2012 to 2014. (46, 74, and 74%, respectively) (eFigure 1).

Postoperative Outcomes

Postoperative weight loss was assessed twelve months after surgery using absolute and relative measures (Table 3). Males lost more weight than females when examining BMI changes (-14.7 ± 8.5 kg/m² vs. -11.7 ± 7.2 kg/m²; $p=0.01$) and net weight loss (-46.1 ± 25.2 kg vs. -31.9 ± 19.2 kg; $p<0.001$). However, %TWL did not differ between the sexes ($-27\pm13\%$ vs. $-24\pm13\%$; $p=0.09$). Similarly, remission rates of ORCs did not differ between males and females.

Comparison of weight loss among races, using both absolute and relative measures, did not reveal statistically significant differences. The remission rates of ORCs were similar among racial cohorts. Weight loss was lower in subjects who underwent AGB than in those who had GB, SG, or other procedures when examining BMI change (-7.6 ± 5.8 kg/m² vs -18.1 ± 5.2 , -15.8 ± 5.4 , -14.9 ± 9.1 kg/m², respectively; $p < 0.001$) and net weight loss (-21.7 ± 16.5 kg/m² vs -51.7 ± 14.4 , -46.0 ± 17.9 , -39.3 ± 24.6 kg/m², respectively; $p < 0.001$). Similarly, assessment of %TWL showed less weight loss after AGB compared to GB, SG, and other procedures ($-16 \pm 10\%$ vs. -35 ± 8 , -32 ± 9 , $-29 \pm 16\%$, respectively; $p < 0.001$). Post-hoc analysis showed that subjects who underwent GB lost 19 units more of %TWL compared to AGB ($p < 0.001$). Conversely, GB was associated with similar weight loss compared to SG ($p = 0.56$) and other procedures ($p = 0.27$).

National Demographic Perspective

In 2013, there were 2,561,405 adolescents with severe obesity in the US. The population distribution by race and sex is represented in Table 4. The ratio of number of Blacks, Hispanics, and Others, to White adolescents with severe obesity was 0.47, 0.49, and 0.04 respectively. The ratio of Blacks, Hispanics, and Others, to White adolescents undergoing bariatric surgery was 0.18, 0.21, and 0.21, respectively. The ROR of obese adolescents versus adolescents undergoing bariatric surgery were as follows: Blacks to Whites 2.6; Hispanics to Whites 2.3; Others to Whites 0.2 (Table 4). Therefore, accounting for the observed racial distribution and each race's severe obesity rate, obese Black and Hispanic adolescents underwent bariatric surgery at a lower-than-expected rate, relative to obese White adolescents (Figure 1).

Discussion

Our study explored the outcomes and utilization of adolescent bariatric surgery using a national comprehensive repository. The characteristics of our study population resemble those previously reported, in which female patients account for 75-80% and Whites represent 65-79% of the adolescents who undergo bariatric surgery^{18,19}.

There are baseline differences in demographics and ORCs observed across our study population both in sex and race stratification. For example, males have higher preoperative BMIs than females. Similarly, Blacks have higher preoperative BMIs as compared to other racial groups. In addition, baseline ORCs differ between females and males; females are more likely to present with depression symptoms whereas males are more likely to have OSA and dyslipidemia. Race also influences ORCs; Whites are more likely to have GERD and depression symptoms and Blacks are more likely to present with hypertension, OSA, and asthma. The impact of sex and race on ORCs has been previously documented.²⁰⁻²² In addition, we observed great variability within individuals of the same racial group, suggesting that not only biologic factors (such as difference in fat distribution and glucose metabolism) but also environmental factors (level of physical activity, diet habits) account for disparities.²³ Most behavioral, social, and environmental factors which affect health (and obesity) disparities are the result of long-term complex, multilevel, dynamic elements.²⁴

The greatest proportion of adolescents underwent GB (43%). This rate is lower than that reported by Kelleher et al. in 2009 using the Kids Inpatient Database (68%),¹⁴ and similar to rates reported by Pallati et al. in 2012 using the University Health Consortium Database.²⁵ This variability can be attributed to the different databases and study time period. AGB represented 39% of the bariatric operations in our cohort. High reoperation rates for complications associated with this procedure have been associated with a decline in the use of AGB in adolescents.^{25,26} Other factors, such as the introduction of the sleeve gastrectomy and age-related limitations based on FDA recommendations for AGB (currently approved for patients ≥ 18 years of age), may also account for this observed shift in the choice of bariatric procedure. Recently, Arapis et al. performed a study involving 897 adult patients who underwent laparoscopic AGB with a mean follow-up of 15 years and reported a long-term failure rate >70%.²⁷ In agreement with Kindel et al., we found that while AGB utilization has decreased over the last several years, SG utilization has increased in adolescents.²⁸ Race stratification shows that the proportion of GB is higher in Blacks (55%) and Hispanics (50%) than in Whites (42%). Similarly, the proportion of Whites who had AGB (43%) was higher than in non-White adolescents. Factors such as patient, parent and surgeon preferences, and culture influence could account for these findings.²⁹ In addition, eligible patients could have declined surgical treatment. Due to the limitations of our study, the contributing factors for these differences remain to be elucidated.

Based on our analysis, race does not significantly impact outcomes. Whereas baseline characteristics were different, weight loss and remission rates of ORCs were similar among races. Racial groups seem to have different remission rate of ORCs after bariatric surgery. However, our stratified analysis did not demonstrate statistically significant differences, potentially due to the attrition rate. Genetic factors, in addition to those directly related to obesity, could explain differences in rates of ORCs among racial groups.³⁰ Moreover, ORCs that are more common in specific races (hypertension in Blacks, depression in Whites) and persist after bariatric surgery will require additional treatment.

Previously, other authors have reported that race impacts weight loss.^{31–34} The variability of weight loss outcome measures utilized by different investigators can make generalization of these findings difficult. We found discrepancies when applying different weight loss outcome measures. For example, BMI absolute change in males was -15 versus -12 BMI units in females, representing a statistically significant difference. However, using relative measures, males had 27 %TWL compared 24 %TWL in females, a non-significant difference. This phenomenon is explained by the baseline differences in weight. In other words, heavier patients need to lose more weight than lighter patients in order to have comparable relative changes.³⁵ Based on our observations, we recommend the use of %TWL to track weight loss and perform comparative analysis of clinical outcomes after bariatric surgery in adolescents. The impact of type of bariatric surgery on weight loss has been extensively studied. Similar to previous findings, we showed that GB and SG are associated with increased weight loss compared to AGB.³⁶ In addition, GB and SG have comparable weight loss outcomes in the adolescent population. Sleeve gastrectomy has gained popularity and its utilization has increased in the last years in both, adolescents and adults.^{28,37}

Underutilization of bariatric surgery in adult minorities is a known phenomenon.¹⁸ However, we have demonstrated that bariatric surgery is underutilized in the adolescent population at a national level. More importantly, we are reporting for the first time, to the best of our knowledge, that minority adolescents, despite being disproportionately affected by obesity, undergo bariatric procedures in a lower proportion relative to Whites.

Our study has several limitations. First, due to the retrospective design of the study, some confounding variables were not collected as the BOLD was not created to study the impact of socioeconomic variables on clinical outcomes. Relevant elements, such as socioeconomic status and primary payer are not part of the database. In addition, adult criteria were used to categorize some of the variables in the database. Therefore, standard pediatric criteria for ORCs such as hypertension and dyslipidemia could not be used. Second, since the BOLD collects data from BSCOE, our results may not be representative of all the bariatric procedures performed nationwide by a broad range of surgical centers. Third, the number of patients with extended follow-up decreases over time and potential differences between patients with and without long-term follow-up may exist. Fourth, the proportion and characteristics of adolescents eligible for bariatric surgery who ultimately decline to undergo the procedure remain unknown.

Conclusion

In accordance with previous studies, we have demonstrated that bariatric surgery is effective in adolescents with severe obesity.^{38–40} Moreover, we identified baseline sex and race disparities and lower-than-expected proportion of adolescent bariatric surgery cases in males and minorities. Our study did not demonstrate racial disparities in outcomes, including weight loss and remission of ORCs. However, we demonstrated baseline disparities and underutilization of bariatric surgery in adolescent minorities. Future research should focus on the evaluation of social determinants of this phenomenon and incorporate a thorough assessment of behavioral components.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

AGB	adjustable gastric banding
BMI	body mass index
BOLD	Bariatric Outcomes Longitudinal Database
BSCOE	Bariatric Surgery Center of Excellence
CPAP	continuous positive airway pressure
DBP	diastolic blood pressure
GB	gastric bypass
GERD	gastroesophageal reflux disease
NHANES	National Health and Nutrition Examination Survey
ORC	obesity-related condition
OSA	Obstructive Sleep Apnea
PPI	proton pump inhibitors
ROR	ratio of ratios
SBP	systolic blood pressure
SRC	Surgical Review Corporation
%TWL	percent of total weight loss

Implications and Contribution

Minority adolescent severe obesity rates have disproportionally increased over the last years. Bariatric surgery is an effective treatment for adolescents with severe obesity but its utilization remains low. This nationwide study demonstrates lower-than-expected rates of bariatric surgery in minority adolescents and the impact of race and sex on outcomes.

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Figure 1. Racial distribution of Adolescent Bariatric Surgery

Accounting for demographic distribution and the specific rates of severe obesity in each racial group, the expected racial distribution of bariatric surgery (upper bar) is presented and compared to the observed racial distribution in our cohort (lower bar).

Table 1
Baseline Characteristics of Adolescents who Underwent Bariatric Surgery

Age at surgery, mean (SD), years	16.9 (2.6)
Sex, No (%)	
Female	1,176 (76)
Male	363 (24)
Total	1,539 (100)
Race, No (%)	
White	962 (63)
Black	175 (11)
Hispanic	203 (13)
Other	199 (13)
Total	1,539 (100)
BMI, mean (SD), kg/m²	48.2 (9.4)
Comorbid Conditions, No (%)	
Hypertension	821 (57)
OSA ^a	376 (24)
GERD ^b	368 (24)
Depression	359 (23)
Asthma	276 (18)
Diabetes	244 (16)
Hyperlipidemia	209 (14)
Bariatric Procedure, No (%)	
Gastric Bypass	656 (43)
Adjustable Gastric Band	600 (39)
Sleeve Gastrectomy	237 (15)
Other ^c	39 (3)

^aObstructive Sleep Apnea

^bGastroesophageal Reflux Disease

^cIntragastric balloon placement or duodenal Switch

Table 2
Preoperative characteristics stratified by sex, race, and type of bariatric procedure

	Females	Males	Total	p-value
Age at surgery, mean (SD), years	16.9 (2.6)	17 (2.5)	16.9 (2.6)	0.63
BMI, mean (SD), kg/m ²	47.1 (8.7)	51.8 (10.5)	48.2 (9.4)	<0.001
Comorbid Conditions, No (%)				
Hypertension	626 (53)	195 (54)	821 (53)	0.50
OSA ^a	263 (22)	113 (31)	376 (24)	<0.001
GERD ^b	293 (25)	74 (20)	367 (24)	0.08
Depression	298 (25)	61 (17)	359 (23)	<0.001
Asthma	210 (18)	65 (18)	275 (18)	0.98
Diabetes	186 (16)	58 (16)	244 (16)	0.93
Dyslipidemia	147 (13)	61 (17)	208 (14)	0.04
Bariatric Procedure, No (%)				
Gastric Bypass	506 (43)	154 (43)	660 (43)	
Adjustable Gastric Band	467 (40)	135 (37)	602 (39)	0.41
Sleeve Gastrectomy	173 (15)	66 (18)	239 (16)	
Other ^c	30 (2)	8 (2)	38 (2)	
	Whites	Blacks	Hispanics	Others
Age at surgery, mean (SD), years	16.9 (2.5)	16.8 (2.8)	16.9 (2.4)	16.9 (2.6)
Sex, No (%)				
Females	739 (77)	137 (78)	151 (74)	149 (75)
Males	223 (23)	38 (22)	52 (26)	50 (25)
BMI, mean (SD), kg/m ²	47.3 (8.3)	52.4 (10.6)	48.7 (8.8)	48.2 (12.1)
Comorbid Conditions, No (%)				
Hypertension	534 (60)	106 (65)	101 (52)	80 (41)
OSA ^a	230 (24)	62 (35)	52 (25)	32 (16)
GERD ^b	258 (27)	39 (22)	43 (21)	28 (14)
Depression	260 (27)	30 (17)	39 (19)	30 (15)

	Females		Males	Total	p-value
Asthma	172 (18)	43 (25)	34 (17)	27 (14)	0.04
Diabetes	142 (14.75)	34 (20)	37 (18)	31 (16)	0.33
Dyslipidemia	132 (14)	22 (13)	30 (15)	25 (13)	0.91
Bariatric Procedure, No (%)					
Gastric Bypass	405 (42)	97 (56)	102 (50)	56 (28)	
Adjustable Gastric Band	413 (43)	55 (31)	67 (33)	67 (34)	<0.001
Sleeve Gastrectomy	118 (12)	19 (11)	29 (14)	73 (37)	
Other ^c	26 (3)	4 (2)	5 (3)	3 (1)	
	Gastric Bypass	Adjustable Gastric Banding	Sleeve Gastrectomy	Other	
BMI, mean (SD), kg/m²	50.4 (9.1)	45.7 (7.3)	48.4 (10.8)	44.1 (9.9)	<0.001
Comorbid Conditions, No (%)					
Hypertension	366 (45)	324 (40)	110 (13)	16 (2)	0.01
OSA ^a	115 (31)	198 (53)	50 (13)	9 (3)	<0.001
GERD ^b	177 (49)	137 (38)	41 (11)	9 (3)	0.02
Depression	159 (45)	136 (38)	49 (14)	10 (3)	0.70
Asthma	130 (48)	107 (39)	25 (9)	9 (3)	0.01
Diabetes	118 (50)	87 (37)	28 (12)	5 (2)	0.10
Dyslipidemia	94 (46)	85 (41)	20 (10)	6 (3)	0.11

^aObstructive Sleep Apnea

^bGastroesophageal Reflux Disease

^cIntra gastric balloon placement and duodenal switch

Table 3
Postoperative outcomes (12 months after surgery) stratified by sex, race, and type of bariatric procedure

	Females	Males			
BMI change, mean (SD), kg/m ²	-11.7 (7.2)	-14.7 (8.5)	0.01		
Net weight loss, mean (SD), kg	-31.9 (19.2)	-46.1 (25.2)	<0.001		
Percent of total weight loss, mean (SD), %	-24 (13)	-27 (13)	0.09		
Resolution of Comorbid Conditions, No (%)					
Hypertension	96 (89)	27 (3)	1.00		
OSA ^a	21 (49)	6 (27)	0.12		
GERD ^b	26 (52)	3 (21)	0.07		
Depression	15 (27)	3 (43)	0.40		
Asthma	7 (18)	4 (36)	0.24		
Diabetes	17 (63)	4 (50)	0.69		
Dyslipidemia	10 (30)	5 (42)	0.50		
	Whites	Blacks	Hispanics	Others	
BMI change, mean (SD), kg/m ²	-12.7 (8.0)	-12.8 (6.8)	-11.6 (6.5)	-10.3 (6.3)	0.59
Net weight loss, mean (SD), kg	-36.4 (22.6)	-34.3 (18.9)	-32.6 (18.9)	-29.1 (17.9)	0.48
Percent of total weight loss, mean (SD), %	-26 (14)	-23 (11)	-23 (12)	-22 (12)	0.45
Resolution of Comorbid Conditions, No (%)					
Hypertension	84 (90)	13 (76)	16 (94)	10 (91)	0.36
OSA ^a	15 (36)	7 (78)	3 (30)	1 (33)	0.10
GERD ^b	21 (40)	4 (100)	3 (75)	1 (25)	0.07
Depression	14 (29)	2 (40)	2 (40)	0 (0)	0.65
Asthma	7 (19)	1 (20)	2 (67)	1 (25)	0.25
Diabetes	13 (62)	9 (86)	0 (0)	2 (40)	0.13
Dyslipidemia	13 (39)	1 (33)	0 (0)	1 (25)	0.39
	Gastric Bypass	Adjustable Gastric Banding	Sleeve Gastrectomy	Other	
BMI change, mean (SD), kg/m ²	-18.1 (5.2)	-7.6 (5.8)	-15.8 (5.4)	-14.9 (9.1)	<0.001
Net weight loss, mean (SD), kg	-51.7 (14.4)	-21.7 (16.5)	-46.0 (17.9)	-39.3 (24.6)	<0.001

	Males		Females		
Percent of total weight loss, mean (SD), %	-29 (16)	-32 (9)	-16 (10)	-35 (8)	
<0.001					
Resolution of Comorbid Conditions, No (%)					
Hypertension	1 (50)	6 (86)	65 (93)	51 (86)	0.14
OSA ^a	1 (33)	1 (25)	8 (33)	16 (50)	0.57
GERD ^b	2 (100)	2 (67)	8 (28)	17 (57)	0.02
Depression	1 (33)	n/a	9 (26)	8 (33)	0.81
Asthma	1 (33)	1 (100)	3 (12)	6 (30)	0.09
Diabetes	n/a	2 (100)	5 (31)	14 (83)	0.01
Dyslipidemia	0 (0)	n/a	5 (21)	10 (50)	0.08

^aObstructive Sleep Apnea

^bGastroesophageal Reflux Disease

Table 4**National Demographic Perspective**

	Whites			Blacks			Hispanics			Other		
	Females	Males	Total	Females	Males	Total	Females	Males	Total	Females	Males	Total
US Census Population (n) ^a	9,387,306	9,899,333	19,286,639	2,510,873	2,595,066	5,105,939	3,715,158	3,494,232	7,209,390	1,393,902	1,434,711	2,828,613
Obesity Rate (NHANES) (%) ^b	7.4	5.9	6.6	12.7	10.7	11.6	8.3	9.2	8.8	0.5	3.3	2.0
Severe Obesity Cases (n) ^c	694,661	584,061	1,278,722	318,881	277,672	596,553	290,021	341,795	631,816	6,970	47,355	54,315
Ratio of Severe Obesity Cases (compared to Whites) ^d	-	-	-	0.46	0.48	0.47	0.42	0.59	0.49	0.01	0.08	0.04
Bariatric Procedures (n) ^e	739	223	962	137	38	175	151	52	203	149	50	199
Ratio of Bariatric Procedures ^f	-	-	-	0.19	0.17	0.18	0.20	0.23	0.21	0.20	0.22	0.21
Ratio of ratios ^g	-	-	-	2.48	2.79	2.56	2.04	2.51	2.34	0.05	0.36	0.21

^a Adolescent population (age 12-19 years), according to 2013 US Census Population data^b Rates of Severe Obesity (120% of 95th percentile) in Adolescents (age 12-19 years), according to NHANES data, years 2013-2014^c Calculation of the number of severe obesity cases in adolescents, using US Census and NHANES data^d Ratio of estimated number of severe obesity cases in each race to estimated number of severe obesity cases in White adolescents^e Number of bariatric surgical procedures stratified by sex and race^f Ratio of number of bariatric procedures in each race to number of bariatric procedures in White adolescents^g Ratio of ratios (d/f)