BARIATRIC PROCEDURES

Approved 5/18/2023

QUESTION ONE

Should bariatric procedures be covered for the treatment of obesity in adults with a body mass index of 35 kg/m^2 or greater?

We recommend coverage for bariatric procedures (including Roux-en-Y gastric bypass, sleeve gastrectomy, biliopancreatic duodenal switch, one anastomosis gastric bypass, single anastomosis duodenal-ileal bypass with gastrectomy) for adults with a body mass index (BMI) ≥ 35 kg/m^2 when the following criteria are met:

A) ≥ 18 years of age

B) Participate in an evaluation by a multidisciplinary team in an MBSAQIP-accredited specialty center:

1. **Psychosocial (conducted by a licensed mental health professional)**
2. **Medical (conducted by a primary care clinician/member of the multidisciplinary team to optimize control of comorbid conditions)**
3. **Surgical (conducted by a bariatric surgeon)**
4. **Nutritional (conducted by a licensed dietician)**

C) Free from active substance use disorder

D) Free from active use of combustible cigarettes

E) Not currently pregnant and documented counseling regarding the need for use of effective contraception for at least 18 months postoperatively, where indicated

F) Agree to adhere to post-surgical evaluation and post-operative care recommendations, some of which may require lifelong adherence

Adjustable gastric banding and intragastric balloons are not recommended for coverage.

Rationale

We recommend coverage because evidence shows these procedures significantly improve type 2 diabetes, hypertension, weight loss, and risk of death. These benefits are considerably greater than the low risk of harms. We have added preoperative eligibility requirements based on clinical guideline standards. Due to a lack of evidence of long-term benefit, adjustable gastric banding and intragastric balloons are not recommended for coverage.

QUESTION TWO

Should bariatric procedures be covered for the treatment of obesity in adults with a body mass index range from 30.0 to 34.9 kg/m²?

We recommend coverage for bariatric procedures in adults with BMI 30.0 to 34.9 kg/m² who, in addition to meeting the above coverage requirements, also have a diagnosis of Type 2 Diabetes Mellitus (T2DM) which has not met clinical glycemic targets despite trials of two diabetes medications.

Rationale

We recommend limiting coverage to patients who have been unable to achieve diabetes control (HbA1c above clinical target) despite trials of two diabetes medications, because medication should be sufficient for many patients to achieve diabetes control. Evidence indicates that these procedures significantly improve weight outcomes and rates of diabetes remission for patients with T2DM, which is greater than the low risk of harms. Evidence is less clear regarding hypertension and other health outcomes, with no evidence reported on risk of death. We have added preoperative eligibility requirements based on clinical guideline standards.

QUESTION THREE

Should bariatric procedures be covered for the treatment of obesity in adolescents?

We recommend coverage for bariatric procedures in adolescents when ALL of the following criteria are met:

A) Age 13-17

B) Participate in an evaluation by a multidisciplinary team in an MBSAQIP-accredited specialty center with Adolescent accreditation:

   1. **Psychosocial (conducted by a licensed mental health professional)**
   2. **Medical (conducted by a primary care clinician/member of the multidisciplinary team to optimize control of comorbid conditions)**
   3. **Surgical (conducted by a bariatric surgeon)**
   4. **Nutritional (conducted by a licensed dietician)**

C) When BMI is:

   1. **≥35kg/m² or 120% of the 95th percentile for age and sex AND a clinically significant comorbid condition; OR**
   2. **≥40kg/m² or 140% of the 95th percentile for age and sex**

D) Agree to adhere to post-surgical evaluation and post-operative care recommendations, some of which may require lifelong adherence.

Rationale

We recommend coverage to align with professional society guidelines and expert input. There are known clinically significant comorbid conditions that are associated with obesity that, if not addressed earlier in the lifecourse, may result in premature morbidity and mortality. We have added preoperative eligibility requirements based on clinical guideline standards.

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RATIONALE FOR DEVELOPMENT OF COVERAGE GUIDANCES AND MULTISECTOR INTERVENTION REPORTS

Coverage guidances are developed to inform coverage recommendations for public and private health plans in Oregon as plan administrators seek to improve patients' experience of care, population health, and the cost-effectiveness of health care. In the era of public and private sector health system transformation, reaching these goals requires a focus on maximizing the benefits and minimizing the harms and costs of health interventions.

The Health Evidence Review Commission (HERC) uses the following principles in selecting topics for its reports to guide public and private payers:

- Represents a significant burden of disease or health problem
- Represents important uncertainty with regard to effectiveness or harms
- Represents important variation or controversy in implementation or practice
- Represents high costs or significant economic impact
- Topic is of high public interest

HERC bases its reports on a review of the best available research applicable to the intervention(s) in question. For coverage guidances, which focus on diagnostic and clinical interventions, evidence is evaluated using an adaptation of the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) methodology. For more information on coverage guidance methodology, see Appendix A.

Multisector interventions can be effective ways to prevent, treat, or manage disease at a population level. In some cases, HERC has reviewed evidence and identified effective interventions, but has not made formal coverage recommendations when these policies are implemented in settings other than traditional health care delivery systems because effectiveness could depend on the environment in which the intervention is implemented.

GRADE Tables

HERC develops recommendations by using the concepts of the GRADE system. GRADE is a transparent and structured process for developing and presenting evidence and for performing the steps involved in developing recommendations. The tables below list the elements that determine the strength of a recommendation. HERC reviews the evidence and assesses each element, which in turn is used to develop the recommendations presented in the coverage guidance box. Estimates of effect are derived from the evidence presented in this document. Assessments of confidence are from the published systematic reviews and meta-analyses, where available and judged to be reliable. The level of confidence in the estimate is determined by HERC based on the assessment of 2 independent reviewers from the Center for Evidence-based Policy (Center; Figure 1).

In some cases, no systematic reviews or meta-analyses encompass the most current literature. In those cases, HERC may describe the additional evidence or alter the assessments of confidence in light of all available information. Such assessments are informed by clinical epidemiologists from the Center. Unless otherwise noted, statements regarding resource allocation, values and preferences, and other considerations are the assessments of HERC, as informed by the evidence reviewed, public testimony, and subcommittee discussion.

GRADE Table Key

Outcomes	Table Key					
	Confidence in Estimate:	NO DATA ○○○○	VERY LOW ●○○○	LOW ●●○○	MODERATE ●●●○	HIGH ●●●●
	Direction of Effect:	NO DATA, UNCLEAR, NO EFFECT, BENEFIT, HARM, MIXED				

Notes. Recommendations for coverage are based on the balance of benefit and harms, resource allocation, values and preferences, and other considerations. See Appendix A for more details about the factors that constitute the GRADE table.
Abbreviation. GRADE: Grading of Recommendations, Assessment, Development, and Evaluations.

GRADE TABLES

POPULATION: Adults with BMI ≥ 35 kg/m²

CRITICAL OUTCOMES

All-cause mortality ●●●○ BENEFIT	Bariatric procedures resulted in a statistically significant reduction in all-cause mortality compared with medical therapy in adults with or without T2DM (3.5 to 8.7 year follow up; range of risk reduction 49% to 71%). Stratified analyses demonstrated a statistically significantly greater effect in mortality for adults with T2DM versus without (59% vs. 30% risk reduction). 3 reviews including 19 comparative cohort studies Moderate confidence based on consistent direction and magnitude of effect; downgraded due to lack of nonobservational data

IMPORTANT OUTCOMES

Weight change ●●●● BENEFIT	Bariatric procedures were associated with statistically significant weight loss in adults with or without T2DM compared with medical therapy. Meta-analyses of 1- to 10-year follow-up data from a review of 19 RCTs found that treatment with surgery resulted in an additional 18.5 kg of weight loss and a BMI reduction of almost 5 kg/m² beyond that experienced by the control group. Patients in trials with higher BMI enrollment requirements and those who received gastric bypass procedures (i.e., RYGB, BPD-DS) vs. non-bypass procedures (e.g., AGB, SG) exhibited greater weight loss compared with nonsurgical obesity interventions. 5 reviews including 36 RCTs and 5 observational studies High confidence based on consistent magnitude, direction, and significance of effect from high-quality study designs with low risk of bias

Improvement or resolution of chronic disease

Diabetes ●●●○ BENEFIT	Statistically significant differences in rates of T2DM remission[a] were observed in adults undergoing bariatric procedures versus medical therapy interventions over 1 to 5 years follow-up (rate of remission 21% to 53% vs. 0 to 16%). In meta-analyses, bariatric surgery was associated with statistically significantly higher 5-year rates of T2DM remission compared with medical therapy (RR range, 6.0 to 16.9; *P* < .001).

POPULATION: Adults with BMI ≥ 35 kg/m²

All bariatric procedure types were associated with increased T2DM remission. At 3 to 5 years follow-up, BPD alone exhibited the greatest differential rate of T2DM remission compared with medical therapy controls (RR, 31.8 [95% CI, 5.0 to 201.8]) followed by RYGB and BPD/DS (RR, 7.5 for both [95% CI, 1.9 to 29.5]) and SG (RR, 6.7 [95% CI, 1.8 to 25.6]).

5 reviews with 28 unique RCTs
Moderate confidence based on consisent direction, magnitude, and significance of effect from pooled results in low risk of bias systematic reviews; downgraded due to varying remission definitions across studies

Hypertension

●●○○ MIXED EFFECTS

The comparative effect of bariatric procedures versus medical therapy on hypertension was mixed. One meta-analysis demonstrated a statistically significant reduction in systolic blood pressure and diastolic blood pressure versus medical therapy (MD, -3.94 mmHg and -2.69 mmHg, respectively). However, subgroup analyses showed no differential effect on blood pressure among individuals younger than 45 years, individuals with baseline BMI less than 40, individuals with baseline HbA1c less than 7.0 percent, and among those who received AGB or BPD/DS.

Reviews limited to adults with T2DM with follow-up of 5 to 10 years demonstrated no between-group difference in systolic blood pressure and an increase in diastolic blood pressure with bariatric procedures.

3 reviews with 20 unique RCTs and 2 comparative cohort studies
Low confidence based on mixed results across blood pressure outcomes and between timepoints and use of a network meta-analyses for primary results

Coronary artery disease

●●○○ BENEFIT

Meta-analyses of RCTs and comparative cohort studies showed statistically significant reductions in the risk of coronary artery disease-related outcomes for bariatric procedures versus medical therapy, including risk of macrovascular complications over 2 to 20 years follow-up (RR range, 0.43 to 0.50 [95% CI, 0.27 to 0.73]); any cardiovascular event (HR, 0.52 [95% CI, 0.39 to 0.71]); and myocardial infarction (RR, 0.46 [95% CI, 0.38 to 0.55]).

2 reviews of 7 RCTs and 6 comparative cohort studies
Low confidence based on risk of bias concerns from contributing systematic reviews, including insufficient search strategies and inclusion of low-quality study designs, and use of results based on some composite outcomes

POPULATION: Adults with BMI ≥ 35 kg/m²

Obstructive sleep apnea NO DATA	No studies met inclusion criteria.
Joint arthropathy NO DATA	No studies met inclusion criteria.
Intracranial hypertension NO DATA	No studies met inclusion criteria.
Quality of life BENEFIT	There was greater improvement in overall and gastrointestinal QoL in the long-term (i.e., ≥ 3 years) with bariatric procedures compared with medical therapy. Results from network meta-analyses showed that bariatric surgery groups had higher mean scores on the Gastrointestinal QoL Index (scoring range, 0 to 144 points) compared with non surgical controls at 3 years (MD range, 17.4 to 25.8 points) and 5 years (MD range, 11.8 to 17.5 points). Additionally, the between-group mean differences exceeded the clinically significant threshold of 5 points for all procedure types. In another review, 3 studies observed higher overall QoL among bariatric surgery groups compared with nonsurgical groups at 5 years, as measured by the SF-36 scale. 2 reviews including 8 RCTs and 6 observational studies Low confidence based on concerns from regarding lack of control for confounding from individual studies in the contributing systematic reviews and use of a composite QoL scale using scores converted from multiple surveys
Harms MIXED EFFECTS	There was no significant difference over 1 to 10 years between bariatric procedures and medical therapy in overall rate of adverse events, nonsurgical serious adverse events, severe hypoglycemia, or death. Evidence on fracture rates was mixed. Bariatric procedures were associated with low rates of perioperative complications (0.1% to 5.1%) such as hernia, internal bleeding, wound

infections, dumping syndrome, and very low rates of perioperative mortality (0.08%).

Five-year revision rates range from 5% to 22% across all assessed bariatric procedure types. Moreover, 10-year estimates (8% to 64%) indicate that need for revision may increase over time.

6 reviews with 40 unique RCTs and 67 observational studies
Low confidence incomplete methods reporting in contributing systematic reviews and a lack of consistent event reporting between reviews and studies

Balance of benefits and harms
The benefits of bariatric procedures in reducing all-cause mortality and T2DM are considerably greater than the risks in adult populations with BMI ≥35 kg/m², with greater benefits for those with pre-existing T2DM.

Resource Allocation
Bariatric procedures are surgically extensive, expensive, and resource intensive. A complete behavioral, physical, and psychological evaluation may help ensure patients meet eligibility criteria and are supported to follow post-operative care recommendations, some of which may require lifelong adherence. Improvement or resolution of comorbid chronic conditions may offset healthcare expenditures in the long term.

Values and Preferences
Patients may value a surgery that could improve important health outcomes and reduce the risk of death. Given the limited evidence on possible harms, as well as a range of benefits associated with bariatric procedures for an individual, a shared decision-making approach may help patients understand the risks, benefits, and alternatives as they apply their values and preferences.

Other considerations
Known complications of surgery should be discussed. All surgical services must be provided by a program with current accreditation (such as a Comprehensive Center or Low Acuity Center) by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) to maintain quality and safety standards.

Given gaps in the evidence, clinical guidelines and expert input may inform coverage decisions regarding specific bariatric procedures or specific populations.

Notes. GRADE table elements are described in Appendix A. A corresponding GRADE Evidence Profile is in Appendix B. [a] T2DM remission was most commonly defined as achieving an HbA1c < 6.0% without ongoing glycemic therapy (e.g., metformin, insulin). Other definitions included fasting plasma glucose targets or different HbA1c thresholds.

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BPD/DS: biliopancreatic diversion with duodenal switch; CI: confidence interval; GRADE: Grading of Recommendations, Assessment, Development, and Evaluations; HbA1c: glycated hemoglobin; HR: hazard ratio; kg/m^2: kilograms per meters squared; MD: mean difference; mmHg: millimeters of mercury; QoL: quality of life; RCT: randomized controlled trial; RR: relative risk or risk ratio; RYGB: Roux-en-Y gastric bypass; SF-36: short form-36 survey; SG: sleeve gastrectomy; T2DM: type 2 diabetes.

POPULATION: Adults with BMI 30.0 to 34.9 kg/m²

CRITICAL OUTCOMES

Outcome	Findings
All-cause mortality NO DATA	No studies met inclusion criteria.

IMPORTANT OUTCOMES

Outcome	Findings
Weight change BENEFIT	Bariatric surgery groups experienced statistically greater percent total body weight loss (22% to 30% vs. 5% to 9%; $P < .001$) and had lower mean BMIs (25 to 28 kg/m² vs. 29 to 32 kg/m²; $P < .001$) compared with medical therapy groups across 1 to 5 years of follow-up. 5 RCTs; N = 391 Moderate certainty based on consistent direction, magnitude, and statistical significance of effect; downgraded for imbalances in baseline characteristics and high control group attrition

Improvement or resolution of chronic disease

Outcome	Findings
Diabetes BENEFIT	Across 1 to 5 years of follow-up, bariatric surgery groups experienced better T2DM outcomes compared with medical therapy, as indicated by comparatively higher rates of remission (RR range, 2.7 to 36.4) and statistically significant lower mean HbA1c values (6.0% to 7.2% vs. 7.5% to 9.1%; $P < .007$) at all reported timepoints. 6 RCTs; N = 433 Low certainty based on consistent findings across 5 years of follow-up; downgraded for differential attrition in control groups and variation in remission definitions across studies
Hypertension UNCLEAR	There were mixed results on the effect of bariatric surgery on hypertension. Pooled analyses of mean systolic and diastolic blood pressure showed inconsistent results across 5 years of follow-up, suggesting that bariatric surgery groups may either have statistically significant lower blood pressure values or no difference compared with medical therapy groups. Both bariatric surgery and medical therapy groups achieved mean blood pressure values at or below the thresholds for hypertension at most follow-up timepoints. 5 RCTs; N = 391

	Very low certainty based on mixed effects across follow-up timepoints in pooled analyses of mean blood pressure values; downgraded forhigh control group attrition, limited number of observations for some timepoints, and mixed effects across outcomes and timepoints
Coronary artery disease ●○○○ UNCLEAR	Only intermediate measures of coronary artery disease risk (e.g., LDL cholesterol and triglycerides concentrations) were available in the included trials. Findings for LDL cholesterol were mixed, with 2 studies observing comparatively higher mean concentrations in surgical vs. medical groups at the longest follow-up and no between-group differences in 3 studies. In contrast, all surgical groups had significantly lower mean triglycerides concentrations over 1 to 5 years of study follow-up compared with medical therapy groups. There were no differences in the use of medications to treat or prevent progression of heart disease (e.g., beta blockers, ACE inhibitors) between groups. 5 RCTs; N = 391 Very low certainty based on mixed effects for intermediate measures associated with increased risk of cardiovascular disease; downgraded for control group attrition, wide confidence intervals, use of intermediate measures, and mixed results
Obstructive sleep apnea ○○○○ NO DATA	No studies met inclusion criteria.
Joint arthropathy ○○○○ NO DATA	No studies met inclusion criteria.
Intracranial hypertension ○○○○ NO DATA	No studies met inclusion criteria.
Quality of life ●○○○ UNCLEAR	At 2 years of follow-up, participants randomized to bariatric surgery had statistically significant higher quality of life scores (SF-36 scale) in most general health domains, except for mental health, compared to medical therapy controls.

POPULATION: Adults with BMI 30.0 to 34.9 kg/m²

	1 RCT; N = 100 Very low certainty based on consistent direction of effect across most domains; downgraded due to imbalances in baseline characteristics, small sample size, and limited population generalizability (non-US with chronic kidney disease)
Harms UNCLEAR	Adverse events were more common in bariatric surgery groups primarily because of early surgical complications. Common adverse events included nausea, dehydration, diarrhea, and upper gastrointestinal pain. Few serious adverse events occurred in any study group. When reported, events were generally related to additional surgeries (e.g., cholecystectomy) or hospitalizations for infection. Rates of reoperation or surgical revisions related to the primary bariatric surgery were not reported. Nutritional abnormalities (only reported in 1 trial) were rare and generally did not differ significantly between study groups, although rates of iron deficiency were higher in the bariatric surgery group at 2 years. 5 RCTs; N = 391 Very low certainty due to control group attrition, low event rates, wide variation in assessed events, and much higher rates of events in 1 trial vs. amost none in other studies

Balance of benefits and harms
The benefits of bariatric procedures for weight reduction and T2DM resolution are greater than the risks in adults with T2DM and BMI 30.0-34.9kg/m²; there is no evidence in populations without diabetes.

Resource Allocation
Similar resource allocation considerations exist for this population; however, given the low level of evidence to support meaningful clinical outcomes, the limited benefits, including weight reduction and resolution of T2DM, may not be sufficient compared to the potential healthcare costs of these procedures, including post-operative maintenance and lifelong adherence standards.

Values and Preferences
Some patients may prefer a surgical treatment option that improves important health outcomes, such as weight loss and T2DM resolution. Other patients may not place as much value on these benefits compared to the risks of surgery. It is important to use shared decision-making to

review the effectiveness of treatment options for patients and offer resources and referrals as appropriate.

Other considerations

Similar considerations for surgical services exist for this population, including complications of surgery and the requirement for procedures to be provided by an accredited program. Given greater uncertainty and gaps in the evidence, recommendations from clinical guidelines and expert input may inform coverage decisions regarding bariatric procedures for this population.

Note. GRADE table elements are described in Appendix A. A corresponding GRADE Evidence Profile is in Appendix B.

Abbreviations. ACE: angiotensin-converting enzyme; BMI: body mass index; GRADE: Grading of Recommendations, Assessment, Development, and Evaluations; HbA1c: glycated hemoglobin; kg: kilogram; kg/m2: kilograms per meter squared; LDL: low density lipoprotein; RCT: randomized controlled trial; RR: relative risk or risk ratio; SF-36: short form-36 survey; T2DM: type 2 diabetes.

POPULATION: Adolescents

CRITICAL OUTCOMES

All-cause mortality

NO DATA

No studies met inclusion criteria.

IMPORTANT OUTCOMES

Weight change

BENEFIT

Bariatric procedures were associated with statistically significant mean BMI reductions (range, -13 to -17 kg/m^2) over 2 to 12 years of follow-up in adolescent cohorts. Where comparative data were available, groups treated with bariatric surgery experienced statistically greater weight reduction than those treated with medical therapy. In 1 study, the surgical group experienced a 5-year mean BMI reduction of -13.1 kg/m^2 compared with a 3.3 kg/m^2 increase in the nonsurgical control group ($P < .001$).

4 cohort studies; N = 525
<u>Low certainty</u> based on statistically significant weight reduction in surgical groups from baseline across 2 to 12 years of follow-up and greater 2 to 5-year weight loss compared with medical groups; downgraded due to imbalances in key study group characteristics at baseline and use of a comparator group from another trial in 1 study

Improvement or resolution of chronic disease

Diabetes

UNCLEAR

Bariatric procedures were associated with high rates of T2DM resolution (86% to 100%) in all adolescent studies compared with no remission reported with medical therapy; however, differing definitions of remission were used among studies. Bariatric surgery was also associated with reductions in fasting plasma glucose compared with medical therapy controls, but results were mixed for HbA1c.

4 cohort studies; N = 525
<u>Very low confidence</u> based on high rates of observed remission in bariatric surgery groups, but limited ability to draw comparative conclusions due to imbalances in key study group characteristics at baseline, few reported remission events across study groups, variation in remission definitions, and conflicting comparative results for some outcomes

POPULATION: Adolescents

Hypertension UNCLEAR	Bariatric procedures were associated with high rates of elevated blood pressure resolution (74% to 100%) at 2 to 12 years follow up versus no remission in medical therapy comparator groups. In comparative stuies, between-group results for mean systolic and diastolic blood pressure were mixed. 4 cohort studies; N = 525 <u>Very low confidence</u> based on imbalances in key study group characteristics at baseline limited number of reported remission events across study groups, and conflicting comparative results
Coronary artery disease UNCLEAR	Only intermediate measures of coronary artery disease risk (e.g., LDL cholesterol and triglycerides concentrations) were available in the included adolescent studies. All bariatric surgery participants with elevated LDL cholesterol and elevated triglycerides (≥ 130 mg/dL) at baseline experienced resolution at 5 years in 1 comparative cohort study, but no control group results were reported for these outcomes. Additionally, 2 comparative studies observed statsitically significant reductions in mean triglycerides in surgical participants compared with medical therapy ($P < .001$), but comparative results for mean LDL cholesterol were mixed. 2 cohort studies; N = 255 <u>Very low confidence</u> based on imbalances in key study group characteristics at baseline, limited number of reported remission events across study groups, use of intermediate measures of cardiovascular disease risk, and conflicting comparative results
Obstructive sleep apnea NO DATA	No studies met inclusion criteria.
Joint arthropathy UNCLEAR	Only intermediate measures of joint arthropathy were available in the included adolescent studies. In 1 study, fewer adolescents who received bariatric surgery reported musculoskeletal pain concerns during physical activity assessments at the 1 year and 2 year postsurgical follow-ups compared with baseline (25% at baseline vs. 8% at 1 year and 12% at 2 years; $P < .01$). 1 cohort study; N = 206

	Very low confidence based on low completion rate of follow-up visits, small sample size, and use of a proxy outcome measure for joint arthropathy
Intracranial hypertension NO DATA	No studies met inclusion criteria.
Quality of life UNCLEAR	In 1 noncomparative study, adolescents who received bariatric surgery reported statistically significant improvements in weight-related physical limitations, self-esteem, and interpersonal relationships at 3 years (IWQoL-Kids scale). Similarly, in 1 comparative study, adolescents who underwent bariatric sugery reported statitically significant reductions in weight-related distress during activities such as shopping, swimming, eating at restaurants, and intimate relations at 5 years (OP-14 scale), but did not experience significantly different changes as compared with adolescents who received medical therapy. In the same comparative study, findings for general QoL (SF-36 scale) were mixed. Compared with medical therapy, bariatric surgery significantly improved physical function but there were no comparative differences in reported mental health, pain, and general health perceptions. 2 cohort studies; N = 395 Very low confidence, based on lack of comparator group and imbalances in some baseline characteristics, mixed comparative general QoL outcomes, and wide confidence intervals for some domains
Harms UNCLEAR	Reported harms varied across studies. Most adverse events in the bariatric surgery groups occurred before hospital discharge and were generally known complications of surgery. The most common long-term harms associated with bariatric surgery were additional abdominal operations, mostly for gall bladder removal, and nutritional abnormalities, which occurred in 45% to 80% of surgical participants. Across 12 years of follow-up, mortality was rare (4 deaths) and was not attributed to surgical causes. However, 2 deaths were related to drug overdose, highlighting the need for substance use support.

POPULATION: Adolescents

	4 cohort studies; N = 525 Very low confidence based on based on imbalances in key study group characteristics at baseline, few reported events for some outcomes, and a lack of consistent adverse events definitions and reporting

Balance of benefits and harms

Despite evidence of weight loss among adolescents, the balance of benefits and harms is unclear due to the lack of comparative data for other outcomes, lack of longer-term follow up given the age of this population, and concern for nutritional deficiencies associated with these procedures.

Resource Allocation

Given the low level of evidence to support meaningful clinical outcomes, the potential benefits of bariatric procedures in adolescents may not be sufficient compared to the potential healthcare costs of these procedures.

Values and Preferences

Adolescents with obesity and their caregivers may desire any treatment that could potentially reduce the future risk for obesity-related chronic illnesses. However, other concerns may include potential risks and side effects of undergoing major abdominal surgery in younger populations, issues with adherence and follow-up, and the potential for future nutritional deficiencies.

Other considerations

Current guidance exists for addressing obesity in adolescents that includes comprehensive, intensive behavioral interventions, which have more data supporting their effectiveness in this population compared with bariatric procedures. In adolescents with severe obesity, referral to a multidisciplinary center for comprehensive assessment may be considered.

Note. GRADE table elements are described in Appendix A. A corresponding GRADE Evidence Profile is in Appendix B.

Abbreviations. BMI: body mass index; GRADE: Grading of Recommendations, Assessment, Development, and Evaluations; HbA1c: glycated hemoglobin; IWQoL Kids: Impact of Weight on Quality of Life Scale for Kids; kg: kilogram; kg/m^2: kilograms per meters squared; LDL: low density lipoprotein; OP-14: Obesity-related Problems Scale-14; QoL: quality of life; SF-36: short form-36 survey; T2DM: type 2 diabetes.

BACKGROUND

Obesity is a complex chronic condition characterized by the retention of excess body fat that may increase an individual's risk of long-term health complications and premature mortality.[1,2] Having a body mass index (BMI)–a measure of an individual's weight in kilograms divided by their height in meters squared (i.e., kg/m^2)–greater than 30 is the generally accepted threshold for obesity, which is further stratified as class I (BMI 30.0 to 34.9), class II (BMI 35.0 to 39.9), and class III (BMI ≥ 40) obesity.[3] Common health morbidities that have been independently linked with obesity include[1]:

- Type 2 diabetes mellitus (T2DM)
- Hypertension
- Asthma
- Sleep apnea
- Osteoarthritis
- Some cancers (e.g., endometrial, gallbladder, esophageal, renal)

State surveys indicate that the prevalence of obesity and obesity-related morbidity in Oregon has been increasing. The Oregon Health Authority estimates that prevalence of obesity among Oregon adults aged 18 years and older was 29.0% in 2017 and the prevalence of diagnosed T2DM was 9.4% in 2015.[4,5] These estimates correspond with a more than two-fold increase in obesity and diabetes prevalence from 1990, when about 10% of adults were identified as having obesity and fewer than 5% had diagnosed T2DM.[4,5] In addition, the 2017 prevalence of obesity among Oregon adolescents, while lower than that of adults, has increased by over 50% since 2001 (7.3% vs. 11.4%).[4]

Although obesity has been increasing among adults and adolescents, certain racial and ethnic groups are disproportionately affected. Among Oregon adults, estimated obesity rates are highest among people who identify as Pacific Islander (45.1%) or as American Indian or Alaska Native (40.6%) and lowest among those who identify as Asian (9.5%).[4] Among Oregon adolescents (i.e., 8th graders), the prevalence of obesity is highest for those who identify as Hispanic or Latino (15.5%) and lowest among Whites (9.9%).[4] It should be noted that the unequal prevalence of obesity across racial and ethnic groups may be due to complex factors including social determinants of health.

The cost impact of obesity in Oregon is substantial. Oregon Health Authority (OHA) estimates the costs for health care and lost productivity due to obesity-related T2DM total nearly $3 billion per year.[5] Annual medical expenditures for T2DM are estimated at $2.2 billion while reduced or lost productivity from T2DM is estimated at around $840 million per year.[5] Oregon Medicaid is disproportionately affected by T2DM, with nearly 19% of beneficiaries having diabetes compared with 7% in employer-sponsored health plans.[5] In 2012, the Oregon Health Plan paid an estimated $106 million in T2DM-related claims, including costs for complications such as cardiovascular events, peripheral artery disease, and retinopathy.[5]

Interventions

First-line nonsurgical interventions for obesity (e.g., nutritional counseling, exercise programs) have been found to offer significant short-term weight loss and remission of obesity-related complications, but these effects are rarely maintained in the long-term.[6-8] In patients who fail to maintain weight loss with nonsurgical interventions (i.e., lifestyle modifications, pharmacotherapy), controlled studies of metabolic or bariatric surgery indicate that these procedures may be effective therapy for the long-term treatment of obesity and common obesity-related morbidities.[1,9-11]

Bariatric procedures may be performed as open surgery or endoscopically, and generally involve restricting the capacity of the stomach or bypassing parts of the small intestine to limit food intake and nutrientabsorption.[2] As shown in Table 1, there are currently 7 primary bariatric procedures endorsed by the American Society for Bariatric and Metabolic Surgeries (ASMBS), including 2 types of US Food and Drug Administration (FDA)-approved devices, the adjustable gastric band and the intragastric balloon.[12]

Table 1. ASMBS-Endorsed Metabolic and Bariatric Procedures

PROCEDURE NAME	STOMACH RESTRICTION	BYPASS PROCEDURE	REVERSIBLE?
Surgical Procedures			
Sleeve Gastrectomy (SG)	80% of the stomach is removed, leaving a banana-shaped "sleeve"	NA	No
Roux-en-Y Gastric Bypass (RYGB)	Stomach is reduced to a pouch the size of an egg or walnut	The stomach pouch is attached to the middle of the small intestine, bypassing about 3-4 feet of small intestine	No
Adjustable Gastric Band (AGB)	Adjustable silicone band[a] is placed around the top of the stomach creating a small pouch; main stomach stays attached	NA	Yes
Biliopancreatic Diversion with Duodenal Switch (BPD/DS)	Similar to SG	The stomach sleeve is attached to the lower small intestine, bypassing 75% of the small intestine	No
Single Anastomosis Duodenal-Ileal Bypass with Sleeve Gastrectomy (SADI-S)	Similar to SG	The stomach sleeve is attached to a loop of small intestine several feet before the end of the small intestine	No
One Anastomosis Gastric Bypass (OAGB)[c]	Similar to SG	The stomach sleeve is attached to a loop from the middle portion of the small intestine	No
Endoscopic Procedures			
Intragastric Balloon (IGB)	Saline-filled silicone balloons[b] temporarily placed in the stomach, limiting amount of food one can eat	NA	Yes

Notes. [a] FDA-approved device: the Lap-Band. [b] FDA-approved devices: Orbera, Reshape, and Obalon. [c] Also known as the mini gastric bypass.
Sources. ASMBS, 2021[13] and ASMBS, 2022.[12]
Abbreviations. AGB: adjustable gastric banding; ASMBS: American Society for Metabolic and Bariatric Surgery; BPD/DS: biliopancreatic diversion with duodenal switch; FDA: United States Food and Drug Administration; IGB: intragastric balloon; NA: not applicable; OAGB: one anastomosis gastric bypass; RYGB: Roux-en-Y gastric bypass; SADI-S: single anastomosis duodenal-ileal bypass with sleeve gastrectomy; SG: sleeve gastrectomy.

According to the ASMBS, approximately 213,000 primary bariatric procedures and 43,000 revisions were performed in the US in 2019, the most recent year for which statistics are available prior to the COVID-19 pandemic.[14] Of the total primary bariatric procedures performed, the majority were sleeve gastrectomy (SG; 71%) or Roux-en-Y gastric bypass procedures (RYGB; 21%).[14] Other procedures made up a comparatively smaller portion of primary bariatric surgeries, with adjustable gastric banding (AGB), biliopancreatic diversion with duodenal switch (BPD/DS), and intragastric balloons (IGB) each accounting for around 2% of procedures.[14] One anastomosis gastric bypass (OAGB) and single anastomosis duodenal ileal bypass with sleeve gastrectomy (SADI-S) procedures were not yet endorsed by the ASMBS in 2019, but each accounted for less than 1% of primary bariatric procedures performed in 2020.[14]

Eligibility and Standard of Care

The current generally accepted criteria for bariatric surgery eligibility were developed in 1991 by the National Institutes of Health (NIH).[15] The guidelines apply to adults ages 18 to 60 years and specify that bariatric procedures should be offered to patients who have a BMI of at least 35 kg/m^2 with obesity-related morbidities or who have a BMI of 40 kg/m^2 with or without comorbidities.[15] Contraindications for bariatric procedures include severe heart or lung disease, uncontrolled psychiatric or substance use disorders, tobacco use, active cancer, inflammatory bowel diseases (for example, Crohn disease), severely impaired intellectual capacity, and current pregnancy.[15] Although the NIH guidelines reflect consensus decisions based largely on expert opinion, they have been continually endorsed by professional societies in the 30 years since they were published.[2,3,16]

Patients who are referred for bariatric procedures must undergo a comprehensive evaluation by a multidisciplinary team experienced in obesity surgery, which typically includes a bariatric surgeon, dietitian, mental health specialist, social worker, and a primary care practitioner.[2,3] During assessment, the care team and the patient collaboratively select the optimal procedure based on the patient's current health status and treatment goals.[3] In the months immediately following a bariatric procedure, patients must adopt a substantially altered diet and are monitored closely for surgical complications. In the long-term, bariatric surgery patients are expected to participate in regular ongoing follow-up including nutritional counseling, vitamin supplementation, and periodic testing to monitor bones density, lipid levels, blood glucose, and serious nutritional deficiencies (e.g., iron, vitamin B12).[3,17]

Access and Equity

Few patients who meet the NIH criteria undergo bariatric procedures. A 2019 study conducted at a large university-based health care system found that only about 5% of patients who met the criteria for bariatric procedures in primary care settings were referred to surgical clinics, suggesting that lack of referrals may be a factor in the low rate of bariatric surgery utilization.[18] Moreover, a recent systematic review found that bariatric surgery referral rates varied by patient characteristics, with male patients, Hispanic patients, and patients with lower BMI less likely to receive referrals than female and White or Black patients with higher BMI.[19] Patients with T2DM and sleep apnea were also more likely to receive referrals compared with patients who had hypertension, dyslipidemia, or heart disease.[19] Ultimately, the authors of the systematic review identified lack of provider familiarity with bariatric surgery efficacy, safety, and postoperative recovery as the primary barrier to patient referrals.[19]

A number of people who may benefit from bariatric procedures fall outside of the clinical eligibility criteria. For example, recent clinical guidelines recommended adjusting BMI criteria for Asian populations who have been shown to experience obesity-related morbidities at a lower BMI compared to other racial and ethnic groups.[2,20] Similarly, population studies have shown that new obesity staging scales that consider the burden of a patient's obesity-related physical and psychologic morbidity alongside their BMI (e.g., the Edmonton Obesity Staging System) are better predictors of all-cause mortality than BMI alone.[2,21,22] These findings suggest that people with BMI 30.0 to 34.9 (i.e., class I obesity) who have significant morbidities could experience a mortality benefit with bariatric procedures beyond that expected for a with a lower-stage patient who has a higher BMI but few obesity-related morbidities.[2,21,22] Age requirements pose an additional eligibility barrier. Despite the known downstream health effects resulting from obesity during adolescence and promising evidence of reduced morbidity after bariatric procedures,[23-25] age under 18 years was found to be the most common reason for coverage denials in a large prospective cohort study of adolescents undergoing bariatric surgery.[26] Older adults (i.e., ages 60 years and older), who are considered to be outside of the recommended NIH age range for bariatric surgery, also experience high rates of age-related coverage denials despite evidence supporting similar outcomes after bariatric procedures as younger adult cohorts.[27]

Among patients who undergo bariatric procedures, outcomes may vary by racial and ethnic identity. Retrospective chart reviews of bariatric surgery patients during the perioperative period have shown that patients who identify as Black have significantly longer lengths of hospital stays as well as higher rates of readmissions, reoperations, and 30-day mortality compared with patients who identify as White.[28] Evidence on longer-term outcome disparities is less conclusive; however, analyses from recent systematic reviews suggests that patients who identify as Black may experience less favorable weight loss outcomes after bariatric procedures than patients who identify as Hispanic or White,[29] but may not differ in terms of comorbidity resolution.[29,30] These disparities in short- and long-term outcomes highlight the need for additional research regarding bariatric surgery access and care.

Accreditation of Surgery Centers

Bariatric surgery programs are accredited through the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP), which is a national program that is jointly administered by the American College of Surgeons (ACS) and the ASMBS.[31] There are currently 6 outpatient and 1 inpatient MBSAQIP accreditation designations that vary in terms of the type of allowed procedures, treatment population, and procedural volume requirements (Table 2). As of January 2023, there are 13 MBSAQIP-accredited bariatric surgery centers in Oregon.[32]

Table 2. MBSAQIP Accreditation Designation Descriptions

DESIGNATION TYPES[a]	BARIATRIC PROCEDURES	POPULATIONS	VOLUME REQUIREMENTS	AVAILABLE IN OREGON?
Accredited Inpatient Centers				
Comprehensive Center	All ASMBS-endorsed procedures[b]	Patients aged ≥ 18 years	≥ 50 bariatric stapling procedures annually	Yes
Comprehensive Center with Adolescent Qualifications	All ASMBS-endorsed procedures	Patients of all ages	≥ 50 bariatric stapling procedures annually	Yes
Comprehensive Center with Obesity Medicine Qualifications	All ASMBS-endorsed procedures	Patients aged ≥ 18 years	≥ 50 bariatric stapling procedures annually	Yes
Comprehensive Center with Adolescent and Obesity	All ASMBS-endorsed procedures	Patients of all ages	≥ 50 bariatric stapling procedures annually	No

Management Qualifications				
Low Acuity Center	ASMBS-endorsed primary procedures AGB replacement, positioning, or removal Port revision or removal Emergent revisional procedures[c]	Ambulatory patients aged ≥ 18 to < 65 years BMI < 55 for males and < 60 for females No history of organ failure or current cardiopulmonary impairment	≥ 25 bariatric procedures annually	Yes
Adolescent Center	All ASMBS-endorsed procedures	Patients aged < 18 years	≥ 15 bariatric stapling procedures annually or utilizes a verified co-surgeon	No
Accredited Outpatient Centers				
Ambulatory Surgery Center	ASMBS-endorsed primary procedures AGB replacement, positioning, or removal Port revision or removal Emergent revisional procedures	Ambulatory patients aged ≥ 18 to < 65 years BMI < 55 for males and < 60 for females No history of organ failure or current cardiopulmonary impairment	≥ 25 bariatric procedures annually	Yes

Notes. [a] Regardless of designation type, all centers must demonstrate compliance with MBSAQIP standard, successfully complete site visits, and enter data into the MBSAQI*P* registry. [b] MBSAQIP-accredited centers must receive approval from an Institutional Review Board to perform primary procedures that are not endorsed by the ASMBS. [c] An emergent case is usually performed within a short interval of time between patient diagnosis or the onset of related preoperative symptomatology. It is understood that the patient's well-being and outcome is potentially threatened by unnecessary delay and the patient's status could deteriorate unpredictably or rapidly.
Source. American College of Surgeons, 2022.[31,32]
Abbreviations. AGB: adjustable gastric banding; ASMBS: American Society for Metabolic and Bariatric Surgeries; BMI: body mass index; MBSAQIP: Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program.

Programs seeking accreditation must demonstrate compliance with MBSAQIP standards regarding facility structures, staff competencies, and data reporting needed to provide quality metabolic and bariatric care. These standards include:

- A dedicated bariatric surgery committee consisting of a director, a coordinator, a clinical reviewer, a pediatric medical advisor (if applicable), an obesity medicine director (if applicable), the clinical staff, and representative from the facility's administration team. The committee is responsible for sharing best practices, discussing adverse events, and conducting quality improvement. [31]
- Multidisciplinary teams capable of providing integrated preoperative, perioperative, and postoperative care for bariatric surgery patients. Programs must be able to provide access or referral to consistent and credentialed surgeons and operating teams, nursing staff, registered dieticians, and mental health professionals. Accredited adolescent centers must also have clinicians specializing in pediatrics for the treatment of pediatric obesity for both medical and behavioral domains.[31]
- Facilities, equipment, and furniture that can accommodate all bariatric surgery candidates. This includes larger beds, wheelchairs, x-ray equipment, and weight-rated or supported toilets.[31]

- Comprehensive patient education and care pathways for patient selection, preoperative behavioral and physical evaluation, nutritional support, and transition plans for pediatric patients to move from a pediatric specialist to an adult program over time.[31]

METHODS

The following sections summarize the overall scope of the evidence review, including Key Questions (KQs) and Contextual Questions (CQs), inclusion and exclusion criteria, and a brief overview of the methods used to conduct the review. Additional information regarding methods can be found in Appendix C.

Key Questions

KQ1. What is the effectiveness of bariatric procedures for the treatment of obesity in adults and adolescents as compared to other treatments?

KQ2. What are the harms of bariatric procedures for the treatment of obesity in adults and adolescents?

KQ3. Is there evidence of differential effectiveness or harms for bariatric procedures by:

a. Age
b. Sex
c. Race/ethnicity
d. BMI category
e. Comparator
f. Whether the patient has received prior bariatric surgery
g. Comorbidities (e.g., medical or behavioral health, disabilities)
h. Site of procedure (e.g., inpatient vs. outpatient surgical center, centers of excellence vs. not)
i. Time since procedure

Contextual Questions

CQ1. What kinds of accreditation standards and center of excellence designations exist in the United States and what are the requirements of each?

CQ2. What is the appropriate minimum age or developmental stage for bariatric surgery?

Study Eligibility Criteria

Table 3 describes the criteria used to inform study selection for the evidence review.

Table 3. Evidence Review Criteria Overview

HEADER	INCLUDE	EXCLUDE
Population	Adults and adolescents with obesity (BMI ≥ 30) who are being considered for bariatric procedures	Adults and adolescents with overweight (BMI < 30)
Interventions	Bariatric procedures (e.g., AGB, RYGB, BPD/DS, SG, OAGB, SADI-S, IGB)	Bariatric devices that are not FDA approved or not available in the United States
Comparators	Nonsurgical treatment of obesity (e.g., medical management, pharmacotherapy, intensive multicomponent behavioral interventions, behavioral counseling, structured weight management programs, other nonsurgical devices or procedures, combinations of these therapies)	Studies comparing bariatric procedures

Outcomes	Critical: all-cause mortality Important: weight change, improvement or resolution of chronic disease, quality of life, harms	Changes in health care utilization
Study Designs	Adults with BMI ≥ 35: systematic reviews of RCTs and cohort studies Adults with BMI 30 to 34.9: RCTs Adolescents: best available prospective literature	Adults with BMI ≥ 35: reviews of small comparative cohort studies (N < 500) or uncontrolled observational studies Adults with BMI 30 to 34.9: nonrandomized studies Adolescents: retrospective studies
Follow-up	Effectiveness: RCTs ≥ 1 year, nonrandomized studies ≥ 3 years Harms: Any time period	--

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BPD/DS: biliopancreatic diversion with duodenal switch; FDA: US Food and Drug Administration; IGB: intragastric balloon; OAGB: one anastomosis gastric bypass; RCT: randomized controlled trial; RYGB: Roux-en-Y gastric bypass; SADI-S: single anastomosis duodenal-ileal bypass with sleeve gastrectomy; SG: sleeve gastrectomy.

Methods Overview

To answer the KQs, we searched multiple clinical evidence databases (e.g., Ovid MEDLINE, Cochrane Library) for published systematic reviews and comparative primary studies evaluating the effectiveness and harms of bariatric procedures as compared with nonsurgical medical interventions for obesity. To meet eligibility criteria, primary studies had to be available in English, include follow-up of at least 1 year, and be published in the past 10 years (i.e., 2012 through 2021); systematic reviews had to be published in the past 3 years (i.e., 2019 through 2021), be available in English, and include a majority (i.e., more than half) of studies that met the inclusion criteria for primary literature. Two reviewers independently examined abstracts and full-text articles for inclusion and assessed the risk of bias (RoB) of included studies. Disagreements were resolved through consensus or by a third reviewer.

Pooled analyses of selected outcomes from included primary trials of adults with BMI 30 to 34.9 were conducted using Review Manager 5.4, Cochrane's systematic review software.[33] Outcomes data were pooled when 2 or more studies reported the same outcome using similar criteria for at least 2 follow-up timepoints in order to better visualize the effects of bariatric surgery over time.

CQs were addressed using studies identified in the KQ database searches. Evidence regarding the CQs is summarized in the Background section; specifically, the *Accreditation of Surgery Centers* subsection for CQ1 and in both the *Access and Equity* background subsection as well as in the summary of evidence-based guidelines for CQ2.

EVIDENCE REVIEW

The following results section organizes findings by 3 key population groups:

- Adults with BMI ≥ 35 kg/m^2
- Adults with BMI 30.0 to 34.9 kg/m^2
- Adolescents

Within each population, results are summarized by outcomes.

Adults with BMI of 35 kg/m² or Greater

We identified 12 systematic reviews[34-45] that reported meta-analyses (MA) or network meta-analyses (NMA), and 1 narrative review[16,46-48] that addressed the scope of this topic. Of the included systematic reviews, 6 limited their analysis to randomized controlled trials (RCTs),[37,38,40,43,45] 4 analyzed only observational studies,[35,36,39,41] and 3 analyzed RCTs and observational studies.[34,42,44] Although the narrative review included mixed study designs, we limited our discussion of the review to studies within it that met our inclusion criteria and had abstractable estimates for eligible outcomes. Table 4 summarizes key characteristics of each included review; see Appendix D, Tables D1 and D2 for additional study characteristics.

Table 4. Characteristics of Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR	RISK OF BIAS	REVIEW POPULATION	NO. OF INCLUDED STUDIES	TOTAL SAMPLE SIZE	FOLLOW-UP RANGE	BARIATRIC SURGERY TYPES	KQS ADDRESSED
SRs of RCTs							
Cresci, 2020[40]	Moderate	Adults with BMI ≥ 35 and T2DM	k = 24	N = 1,351	6 months to 5 years	AGB, BPD/DS, OAGB, RYGB, SG	KQ1, KQ2, KQ3
Cui, 2021[38]	Moderate	Adults with BMI ≥ 35 and T2DM	k = 7	N = 447	1 to 5 years	RYGB	KQ1
Khorgami, 2019[45]	Moderate	Adults with BMI ≥ 35 and T2DM	k = 7	N = 463	2 to 5 years	AGB, BPD/DS, RYGB, SG	KQ1, KQ3
Park, 2019[43]	Low	Adults with BMI ≥ 35	k = 45	N = 4,089	6 months to 5 years	AGB, BPD/DS, OAGB, RYGB, SG, VBG	KQ1, KQ2, KQ3
Wang, 2021[37]	Low	Adults with BMI ≥ 35	k = 19	N = 663	1 to 10 years	AGB, BPD/DS, RYGB, SG	KQ1, KQ2, KQ3
SRs of Mixed Study Designs							
Ablett, 2019[44]	Moderate	Adults with BMI ≥ 35	k = 9	N = 283,405	2 to 8.9 years	AGB, RYGB, SG	KQ1, KQ2
Malczak, 2021[34]	High	Adults with BMI ≥ 35	k = 47	N = 26,629	NR	BPD/DS, OAGB, RYGB, SG	KQ1
Yan, 2019[42]	Moderate	Adults with BMI ≥ 35 and T2DM	k = 10	N = 50,150	5 to 15 years	AGB, BPD/DS, ESG, RYGB, SG	KQ1, KQ3
SRs of Observational Studies							
Hussain, 2021[39]	High	Adults with BMI ≥ 35 and T2DM	k = 5	N = 49,211	1.8 to 18.1 years	AGB, BPD/DS, RYGB	KQ1
Pontiroli, 2020[41]	Moderate	Adults with BMI ≥ 35	k = 9	N = 607,643	4 to 14 years	BPD/DS, RYGB, SG	KQ1, KQ3
Robertson, 2020[35]	High	Adults with BMI ≥ 35	k = 58	N = 3,650,961	In-hospital to 90 days post-surgery	AGB, BPD/DS, OAGB, RYGB, SG	KQ2, KQ3
Syn, 2021[36]	Low	Adults with BMI ≥ 35	k = 17	N = 174,772	2.6 to 24 years	AGB, BPD/DS, OAGB, RYGB, SG	KQ1, KQ3
Narrative Reviews							

AUTHOR, YEAR	RISK OF BIAS	REVIEW POPULATION	NO. OF INCLUDED STUDIES	TOTAL SAMPLE SIZE	FOLLOW-UP RANGE	BARIATRIC SURGERY TYPES	KQS ADDRESSED
Arterburn, 2020[16]	High	Adults with BMI ≥ 35	k = 12 (T2DM only)	N = 874	1 to 5 years	AGB, BPD/DS, RYGB, SG	KQ1

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BPD/DS: biliopancreatic diversion with duodenal switch; ESG: endoscopic sleeve gastroplasty; KQ: Key Question; No.: number; NR: not reported; OAGB: one anastomosis gastric bypass; RCT: randomized controlled trials; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; SR: systematic review; T2DM: type 2 diabetes mellitus; VBG: vertical banded gastroplasty.

Taken together, these reviews represent 59 unique RCTs and 118 unique observational studies from the rapidly growing field of bariatric research. It should be noted that there is considerable overlap among our included reviews in terms of the primary RCTs they include, with most reviews including some or all of 12 common RCTs comparing bariatric procedures with medical therapy. Conversely, there was almost no overlap among the comparative cohort studies included across our eligible reviews.

We rated 3 systematic reviews as having a low RoB, 7 as moderate RoB, and 3 as high RoB; all narrative reviews were rated as having a high RoB (Table 4; Appendix C). Reviews with moderate and high RoB ratings generally lacked complete methods reporting, did not account for potential publication bias, and did not adequately incorporate RoB of the primary studies into the review conclusions. In addition to RoB considerations, included reviews were inconsistent in reporting sample sizes and time points associated for MA and NMA results, which further limited the overall strength of evidence.

We focused on comparative studies of bariatric procedures versus nonsurgical medical therapy interventions (i.e., medical therapy) for obesity. Included reviews assessed all ASMBS-endorsed bariatric procedures except for intragastric balloons and SADI-S. Medical therapy comparator groups included interventions such as behavioral lifestyle interventions, pharmacotherapy, and combination therapy. Most reviews broadly compared bariatric procedures with any eligible medical therapy. Studies of harms did not require a comparator. Findings from relevant systematic reviews form the core of the evidence review results, with reviews of RCTs receiving priority over reviews with mixed or observational-only study designs; narrative reviews were used to fill gaps in the evidence that were not addressed by systematic reviews.

All-cause Mortality

Three reviews analyzed all-cause mortality reported in at least 19 unique comparative cohort studies, each with over 500 participants (Table 5; Appendix D, Table D3).[36,39,41] Eligible reviews ranged from low- to high-risk of bias and included studies of adults with BMI ≥ 35 with or without T2DM. The primary reported outcome was the comparative risk of all-cause mortality between bariatric surgery participants and controls, which was generally expressed as a cumulative ratio. When possible, ratios were described in the context of differential risk reduction percentages.

Table 5. All-cause Mortality Outcomes from Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF OBSERVATIONAL STUDIES	EFFECT ESTIMATE[a,b] (95% CI)	*P* VALUE
Hussain, 2021[39] High	Adults with BMI ≥ 35 and T2DM	Risk of all-cause mortality	3.5 to 4.7 years (median)	2	RR, 0.39 (0.30 to 0.50)	$P < .001$
Pontiroli, 2020[41] Moderate	Adults with BMI ≥ 35	Global mortality	8.7 years (mean)	9	OR, 0.29 (0.17 to 0.49)	$P = .001$
Syn, 2021[36] Low	Adults with BMI ≥ 35	Cumulative all-cause mortality	5.8 years (median)	17	HR, 0.51 (0.48 to 0.54)	$P < .001$
		Change in median life expectancy	5.8 years (median)	17	+6.1 years (5.2 to 6.9)	NR

Notes. [a] Unless otherwise noted, effect estimates for systematic reviews represent between-group comparisons for bariatric procedures vs. medical therapy controls. [b] Ratio-based estimates less than 1 may be inverted to estimate the percentage risk reduction with bariatric procedures. For example, (1 – 0.39)*100% = 61% risk reduction with bariatric procedures vs. controls.
Abbreviations. BMI: body mass index; CI: confidence interval; HR: hazard ratio; No.: number; NR: not reported; OR: odds ratio; ROB: risk of bias; RR: relative risk or risk ratio; T2DM: type 2 diabetes mellitus.

Two reviews estimated all-cause mortality from studies of general adult populations with a BMI 35 or greater, with or without comorbidities.[36,41] A 2021 review that included a meta-analysis of 17 comparative observational studies with follow-up ranging from 2.6 to 24 years provided the most robust mortality data.[36] In this analysis, Syn and colleagues estimated that patients who received bariatric procedures had a 49% lower risk of all-cause mortality (i.e., hazard ratio [HR], 0.51), corresponding with an additional 6.1 years of median life expectancy, compared with matched medical controls at 5.8 years of median follow-up ($P < .001$).[36] Another moderate-RoB review and meta-analysis of 9 observational studies estimated that bariatric surgery patients had a 71% reduced risk of all-cause mortality at 8.7 years of mean follow-up ($P = .001$), suggesting a persistent benefit of bariatric surgery over time.[41]

Adults with BMI ≥ 35 and T2DM

Two reviews reported all-cause mortality estimates in adults with BMI 35 or greater and T2DM (Table 5).[36,39] A meta-analysis of 2 large US-based registry studies from a high-RoB systematic review (SR) conducted by Hussain and colleagues found that bariatric procedures reduced the 3 to 5 year risk of all-cause mortality by 61% compared with nonsurgical interventions in adults with obesity and T2DM ($P < .001$).[39] This finding aligns with the differential risk reductions reported for general adult bariatric surgery populations in the prior section. However, subgroup analyses in the review conducted by Syn and colleagues (Appendix D, Table D3) showed that while individuals with and without T2DM who underwent bariatric procedures experienced significantly reduced risk of all-cause mortality compared to controls at 5.8 years of follow-up, the mortality effect of bariatric procedures was significantly greater among adults with T2DM (comparative risk reduction: 59% with T2DM vs. 30% without T2DM; $P < .001$).[36] For that same follow-up period, individuals with T2DM also experienced a greater differential gain in life expectancy with bariatric procedures (+9.1 years) compared with individuals without T2DM (+ 5.1 years).[36]

Other Subgroup Analyses

All-cause mortality subgroup analyses were also available by age and bariatric procedure type (Appendix D, Table D3). Age-stratified analyses conducted by Pontiroli and colleagues showed that the estimated all-cause mortality treatment effect between individuals treated with bariatric procedures compared with medical therapy was not significant for individuals below the median cohort analysis age for each study (odds ratio [OR], 0.78 [95% confidence interval [CI], 0.57 to 1.06]; *P* = .110), but was significant for individuals above the median cohort age (OR, 0.23 [95% CI, 0.12 to 0.44]; *P* < .001).[41] In contrast, Syn and colleagues found that while all major bariatric procedure types assessed in the included primary studies (i.e., AGB, RYGB, SG) were associated with significant reductions in all-cause mortality risk compared to medical therapy controls (HR range, 0.43 to 0.50; *P* < .001), there was no differential mortality benefit associated with any specific procedure (*P* = .36).[36]

Weight Change

Five reviews[37,40,42-44] analyzed weight change outcomes in adults with BMI of 35 or greater (Table 6). Except for SADI-S, weight change analyses included all ASMBS-endorsed procedures. Currently, there is no standardized measure for assessing weight change, and among the included reviews, weight change was assessed by a range of measures including absolute change in kilograms or BMI units or the proportion of total or excess weight loss during follow-up. Results reported in Table 6 largely reflect overall estimates of between-group (i.e., bariatric procedures vs. medical therapy) outcomes.

Table 6. Weight Change Outcomes from Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	EFFECT ESTIMATE[a] (95% CI)	*P* VALUE
Ablett, 2019[44] Moderate	Adults with BMI ≥ 35	Mean weight change (kg)	2 years	3 RCTs	MD, -22.2 (-31.6 to -12.8)	*P* < .001
Cresci, 2020[40] Moderate	Adults with BMI ≥ 35 and T2DM	% Total weight loss	1 to 5 years	9 RCTs	MD, -16.83 (-18.03 to -15.62)	*P* < .001
		Mean BMI change (kg/m²)	1 to 5 years	10 RCTs	MD, -5.74 (-7.05 to -4.43)	*P* < .001
Park, 2019[43] Low	Adults with BMI ≥ 35	% Excess weight loss	1 year	24 RCTs	No overall estimate MD range by procedure type: 26.9% to 70.7%	*P* < .05 for all
			2 years	14 RCTs	No overall estimate MD range by procedure type: 52.8% to 75.0%	*P* < .05 for all
			3 years	9 RCTs	No overall estimate MD range by procedure type: 19.0% to 45.0%	*P* < .05 for all

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	EFFECT ESTIMATE[a] (95% CI)	*P* VALUE
Wang, 2021[37] Low	Adults with BMI ≥ 35	Mean weight change (kg)	1 to 10 years	19 RCTs	MD, -18.47 (-22.99 to -13.93)	*P* < .001
		Mean BMI change (kg/m^2)	1 to 10 years	12 RCTs	MD, -4.79 (-7.92 to -1.66)	*P* < .001
Yan, 2019[42] Moderate	Adults with BMI ≥ 40 and T2DM	Mean BMI change (kg/m^2)	5 to 10 years	2 RCTs and 2 OS	MD, -8.49 (-15.01 to -1.98)	NR

Note. [a] Unless otherwise noted, effect estimates for SRs represent between-group comparisons for bariatric procedures vs. medical therapy controls. Effect estimates from NRs are raw estimates as no MAs or NMAs were performed.

Abbreviations. BMI: body mass index; CI: confidence interval; kg: kilogram; m^2: meters squared; MA: meta-analysis; MD: mean difference; NMA: network meta-analysis; No.: number; NR: not reported; OS: observational studies; RCT: randomized controlled trial; ROB: risk of bias; SR: systematic review; T2DM: type 2 diabetes mellitus.

Three low- to moderate-RoB SRs reported weight change outcomes for general adult populations with BMI 35 or greater (Table 6; Appendix D, Table D3).[37,43,44] The most comprehensive direct evidence for this population comes from a 2021 SR of RCTs comparing bariatric procedures with nonsurgical treatment for obesity.[37] Based on meta-analyses of 1- to 10-year follow-up data from 19 RCTs, Wang and colleagues estimated that treatment with bariatric procedures resulted in an additional 18.5 kg of weight loss and a BMI reduction of almost 5 kg/m^2 compared with nonsurgical control group participants.[37] Results from a meta-analysis of 3 RCTs in a 2019 SR were similar, with adults who were randomized to bariatric procedures experiencing an estimated additional 22.2 kg of weight loss compared with medical controls.[44] Indirect evidence from a 2019 network meta-analysis of excess weight loss in 24 RCTs conducted by Park and colleagues support the direct results generated by the previously described meta-analyses.[43] Although no overall network analyses were reported, patients randomized to bariatric procedures experienced proportionally greater excess weight loss with AGB, BPD/DS, RYGB, and SG procedures compared with medical controls at both 1 and 3 years.[43] Differential weight loss was highest at 2 years, with bariatric surgery patients experiencing around 53% to 75% more excess weight reduction than controls.[43]

Adults with BMI ≥ 35 and T2DM

Two moderate-RoB SRs analyzed weight change outcomes from studies of adults with T2DM (Table 6).[40,42] Based on a network meta-analysis of RCTs with 1- to 5-year follow-up, Cresci and colleagues estimated that adults with T2DM who were randomized to bariatric procedures lost around 17% more weight than medical controls, corresponding with a differential BMI reduction of almost 6 kg/m^2.[40] Two SRs indicate that these short-term differential weight reductions observed among T2DM patients with bariatric procedures may be maintained in the long-term. A meta-analysis of RCTs and observational studies conducted by Yan and colleagues estimated that at 5 to 10 years follow-up, T2DM patients treated with bariatric surgery experienced a differential BMI reduction of 8.5 kg/m^2 compared to controls.[42]

Other Subgroup Analyses

Included reviews conducted weight change subgroup analyses by bariatric procedure type, trial BMI criteria, and trial duration (Appendix D, Table D3). Four reviews reported comparative weight change by bariatric procedure type.[37,40,42,43] With rare exceptions, patients who received one of the common bariatric procedures (i.e., AGB, BPD/DS, RYGB, SG) experienced significantly greater weight loss at all follow-up time points compared with medical controls. More recently endorsed ASMBS procedures, such as the OAGB, also exhibited greater short-term weight loss in meta-analyses compared with medical controls. In general, AGB and SG resulted in lower differential weight compared with RYGB and BPD/DS.

In addition to procedure type, Cresci and colleagues conducted subgroup analyses by minimum trial BMI requirements and trial duration as part of a network meta-analysis of RCTs. Although participants who underwent bariatric procedures experienced statistically significant reductions in mean BMI compared with nonsurgical controls, regardless of the trial BMI enrollment threshold, there was a smaller but statistically significant reduction in BMI for intervention groups in trials with BMI enrollment thresholds below 35 kg/m^2.[40] However, there were no differences in BMI reduction by overall trial follow-up duration (i.e., ≤ 2 years vs. > 2 years).[40]

Change in Chronic Disease Status

We assessed the effect of bariatric surgery on improvement or resolution of several obesity-related chronic conditions. The conditions selected for this evidence review include T2DM, hypertension (HTN), coronary artery disease (CAD), obstructive sleep apnea (OSA), joint arthropathy, and intracranial HTN. We prioritized evidence regarding condition resolution and presented evidence regarding improvement when resolution data were not available. No studies meeting inclusion criteria reported on clinical outcomes or joint arthropathy or intracranial HTN.

Diabetes

Five reviews[37,38,40,43,45,48] analyzed improvement or resolution in diabetes in adults with BMI of 35 or greater (Table 7; Appendix D, Table D4). Diabetes data were exclusively focused on T2DM populations, and we did not identify any reviews assessing the effect of bariatric procedures on type 1 diabetes. Most eligible reviews reported on T2DM remission, which was most commonly defined as achieving an HbA1c < 6.0% without ongoing glycemic therapy (e.g., metformin, insulin). Other definitions included fasting plasma glucose (FPG) targets or different HbA1c thresholds.

Table 7. Diabetes Outcomes from Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	RATE, INTEVENTION VS. CONTROL EFFECT ESTIMATE [a] (95% CI)	*P* VALUE
Cresci, 2020[40] Moderate	Adults with BMI ≥ 35 and T2DM	T2DM remission	1 to 5 years	9 RCTs	34.6% vs. 1.9% OR, 19.26 (5.68 to 65.31)	*P* = .001
Cui, 2021[38] Moderate	Adults with BMI ≥ 35 and T2DM	T2DM remission	1 year	4 RCTs	28.2% vs. 0.6% RR, 18.01 (4.53 to 71.70)	*P* < .001
			2 years	4 RCTs	54.8% vs. 16.4% RR, 12.70 (0.45 to 358.63)	*P* = .14

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	RATE, INTEVENTION VS. CONTROL EFFECT ESTIMATE [a] (95% CI)	P VALUE
			3 years	3 RCTs	35.1% vs. 0 RR, 29.58 (5.92 to 147.82)	*P* < .001
			5 years	3 RCTs	21.4% vs. 0 RR, 16.92 (4.15 to 69.00)	*P* < .001
Khorgami, 2019[45] Moderate	Adults with BMI ≥ 35 and T2DM	T2DM remission	2 years	7 RCTs	52.5% vs. 3.5% RR, 10.0 (5.5 to 17.9)	*P* < .001
			5 years	4 RCTs	27.5% vs. 4.5% RR, 6.0 (2.7 to 13.0)	*P* < .001
Park, 2019[43] Low	Adults with BMI ≥ 35	T2DM remission	1 to 2 years	15 RCTs	Overall estimates NR RR range across procedure types: 7.6 to 14.3	*P* < .001 for all
			3 to 5 years	11 RCTs	Overall estimates NR RR range across procedure types: 6.7 to 31.8	*P* < .001 for all
Wang, 2021[37] Low	Adults with BMI ≥ 35	Reduced use of metformin	1 to 5 years	IG: 6 RCTs CG: 5 RCTs	IG: RR, 0.46 (0.25 to 0.87) CG: RR, 0.98 (0.81 to 1.19)	*P* = .02 *P* = .83
		Reduced use of insulin	1 to 5 years	IG: 13 RCTs CG: 9 RCTs	IG: RR, 0.35 (0.23 to 0.52) CG: RR, 0.93 (0.75 to 1.16)	*P* < .001 *P* = .54
		Reduced use of other T2DM drugs	1 to 5 years	IG: 9 RCTs CG: 7 RCTs	IG: RR, 0.55 (0.42 to 0.72) CG: RR, 0.89 (0.80 to 0.99)	*P* < .001 *P* = .04

Notes. [a] Unless otherwise noted, effect estimates for SRs represent between-group comparisons for bariatric procedures vs. medical therapy controls. Effect estimates from NRs are raw estimates as no MAs or NMAs were performed. [b] Results for bariatric surgery groups only.
Abbreviations. BMI: body mass index; CG: control group; CI: confidence interval; IG: intervention group; MA: meta-analysis; NMA: network meta-analysis; No.: number; NR: not reported; OR: odds ratio; RCT: randomized controlled trial; ROB: risk of bias; RR: relative risk or risk ratio; SR: systematic review; T2DM: type 2 diabetes mellitus.

Five moderate- to low-RoB reviews assessed diabetes outcomes in adults with BMI of 35 kg/m^2 or greater (Table 7).[37,38,40,43,45] Of these reviews, 4 reported T2DM remission with 1 to 5 years of available follow-up data.[38,40,43,45] Across all follow-up periods, remission rates ranged from 21.4% to 52.5% with bariatric procedures compared with 0 to 16.4% with medical therapy; comparative estimates from meta-analyses showed that the likelihood of remission with bariatric procedures was significantly higher compared with medical therapy (relative risk [RR] range, 6.0 to 16.9; $P < .001$).[38,40,43,45] Rates of remission were generally higher in both intervention and control groups during short-term follow-up (i.e., 1 to 2 years), but the comparative likelihood of remission during this period (RR range, 7.6 to 18.01) was not statistically higher compared with longer-term follow-up (RR range, 6.0 to 31.8).[38,40,43,45] Subgroup analyses by bariatric procedure type from a network meta-analysis showed that all major bariatric procedures were associated with increased likelihood of short- and long-term T2DM remission compared with medical controls, with AGB having the smallest relative effect and gastric bypass procedures having the largest remission effect (Appendix D, Table D4).[43]

One review reported on changes in participants' use of key elements of glycemic therapy for T2DM (Table 7; Appendix D, Table D4).[37] Over 1 to 5 years of follow-up, Wang and colleagues found that groups randomized to bariatric procedures demonstrated a statistically significant reduction in the use of metformin and insulin compared with nonsurgical weight loss groups.[37] In comparison, there were no between-group differences in use of other antidiabetic medications.[37]

Hypertension

Three reviews[37,40,42,47,48] analyzed improvement or resolution of HTN in adults with BMIs of 35 or greater and several key subpopulations (Table 8; Appendix D, Table D4). HTN is defined by the American Heart Association as having a systolic blood pressure of 130 mmHg or higher or a diastolic blood pressure of 80 mmHg or higher[49]; blood pressures above these thresholds have been linked to increased risk for adverse cardiovascular outcomes, including stroke and myocardial infarction.[50] Most reviews reported measures of HTN improvement, including mean and percent change in systolic and diastolic blood pressure. HTN resolution or remission was generally measured by the cessation of antihypertensive medications at follow-up, although some definitions required patients to meet a systolic blood pressure target without the use of medications.

Table 8. Hypertension Outcomes from Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	IG vs. CG RATE EFFECT ESTIMATE [a] (95% CI)	*P* VALUE
Cresci, 2020[40] Moderate	Adults with BMI ≥ 35 and T2DM	Mean change in SBP (mmHg)	1 to 5 years	9 RCTs	MD, -2.62 mmHg (-4.46 to -0.79)	*P* = .005
		Mean change in DBP (mmHg)	1 to 5 years	9 RCTs	MD, 0.91 mmHg (-1.54 to 3.36)	*P* = .46
		Mean change in % using antiHTN drugs from baseline	2 to 5 years	2 RCTs	IG range: -28 to -48 percentage points CG range: 0 to +10 percentage points	NR
Wang, 2021[37] Low	Adults with BMI ≥ 35	Mean change in SBP (mmHg)	1 to 5 years	19 RCTs	WMD, -3.94 mmHg (-6.00 to -1.88)	*P* < .001
		Mean change in DBP (mmHg)	1 to 5 years	19 RCTs	WMD, -2.69 mmHg (-3.99 to -1.39)	*P* < .001
		Mean change in % using antiHTN drugs	1 to 5 years	IG: 5 RCTs CG: 5 RCTs	Baseline vs. follow-up by group IG: 67.3% vs. 37.3% MD, -0.91 per capita reduction (-1.49 to -0.33) CG: 70.9% vs. 68.4% MD, -0.05 per capita reduction (-0.39 to 0.29)	*P* = .002 *P* = .78

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	IG vs. CG RATE EFFECT ESTIMATE [a] (95% CI)	*P* VALUE
Yan, 2019[42] Moderate	Adults with BMI ≥ 40 and T2DM	Mean change in SBP (mmHg)	5 to 10 years	2 RCTs and 2 OS	WMD, 0.00 (-0.11 to 0.11)	NR
		Mean change in DBP (mmHg)	5 to 10 years	2 RCTs and 2 OS	WMD, 0.90 (0.82 to 0.97)	NR

Notes. [a] Unless otherwise noted, effect estimates for SRs represent between-group comparisons for bariatric procedures vs. medical therapy controls. Effect estimates from NRs are raw estimates as no MAs or NMAs were performed. [b] Remission definition: SBP < 130 mmHg at 12 months and without the use of antihypertensive medication.

Abbreviations. BMI: body mass index; CG: control group; CI: confidence interval; DBP: diastolic blood pressure; HTN: hypertension; IG: intervention group; MA: meta-analysis; MD: mean difference; mmHg: millimeters of mercury; NMA: network meta-analysis; No.: number; NR: not reported; OS: observational studies; RCT: randomized controlled trial; ROB: risk of bias; SBP: systolic blood pressure; SR: systematic review; T2DM: type 2 diabetes mellitus; WMD: weighted mean difference.

Three moderate- to low-RoB reviews assessed blood pressure outcomes in adults with BMI of 35 kg/m^2 or greater (Table 8).[37,40,42] A low-RoB 2021 SR of RCTs, conducted by Wang and colleagues, provided the most comprehensive and direct estimates of short- to mid-term (i.e., 1 to 5 years) HTN outcomes in this population. Based on a meta-analysis of 19 RCTs, bariatric surgery was associated with a statistically significant reduction in systolic blood pressure and diastolic blood pressure compared to medical therapy (mean difference [MD], -3.94 mmHg and -2.69 mmHg, respectively). Subgroup analyses showed a statistically significant reduction in systolic blood pressure and diastolic blood pressure among patients with higher age (≥ 45 years), higher baseline BMI (≥ 40 kg/m^2), higher baseline HbA1c (≥ 7.0%), and among those who underwent RYGB. In contrast, there were no between-group differences in mean systolic blood pressure or diastolic blood pressure at follow-up among patients with lower age (< 45 years), lower baseline BMI (< 40 kg/m^2), lower baseline HbA1c (< 7.0%), and those who received AGB or BPD/DS (Appendix D, Table D4). In a meta-analysis of antihypertensive medication use from 5 RCTs, there was a significant within-group reduction from baseline in the use of medications among patients randomized to bariatric procedures (67.3% vs. 37.3%; *P* = .002); in contrast, patients randomized to nonsurgical control groups did not experience a significant reduction in medication use (*P* = .78). These findings suggest that bariatric procedures may result in better blood pressure control and a higher rate of HTN remission than medical therapy for obesity among adult populations with BMI of 35 or greater, with or without comorbidities.

Two reviews assessed HTN outcomes for adults with BMI 35 or greater and T2DM (Table 8) and reported mixed results.[40,42] Results from 1 network meta-analysis of 9 RCTs, conducted by Cresci and colleagues, reported a statistically significant reduction in systolic blood pressure for bariatric procedures versus medical therapy over 1 to 5 years of follow-up (MD, -2.62 mmHg; *P* =.005), but no difference in diastolic blood pressure.[40] However, another meta-analyses of longer-term data (i.e., 5 to 10 years) from RCTs and comparative observational studies of adults with obesity and T2DM, conducted by Yan and colleagues, found no difference in systolic blood pressure with bariatric procedures compared with medical therapy and indicated that bariatric procedures may be associated with increased diastolic blood pressure (MD, 0.90 mmHg).[42]

Coronary Artery Disease

Two moderate- to high-RoB reviews[39,42] analyzed coronary artery disease-related outcomes in adults with BMIs of 35 or greater and several key subpopulations (Table 9; Appendix D, Table D4). Key outcomes for this category ranged from specific events (e.g., myocardial infarction [MI]) to broad categories, such as cardiovascular events. Both reviews assessed macrovascular complications, which is a composite outcome that includes cerebrovascular incidents such as stroke, and coronary artery disease-related incidents such as myocardial infarction.

Table 9. Cardiovascular-Related Outcomes from Included Reviews in Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	IG vs. CG RATE EFFECT ESTIMATE [a] (95% CI)	*P* VALUE
Hussain, 2021[39] High	Adults with BMI ≥ 35 and T2DM	Macrovascular complications	1.8 to 18.1 years	5 OS	RR, 0.50 (0.35 to 0.73) Adj. RR, 0.54 (0.37 to 0.79)	*P* = .003 *P* = .002
Yan, 2019[42] Moderate	Adults with BMI ≥ 40 and T2DM	Macrovascular complications	5 to 20 years	3 RCTs and 6 OS	3.4% vs. 7.2% RR, 0.43 (0.27 to 0.70)	NR
		Cardiovascular events		1 RCT and 2 OS	HR, 0.52 (0.39 to 0.71)	NR
		Myocardial infarction	5 to 20 years	3 RCTs and 4 OS	1.0% vs. 2.2% RR, 0.46 (0.38 to 0.55)	NR

Note. [a] Unless otherwise noted, effect estimates for SRs represent between-group comparisons for bariatric procedures vs. medical therapy controls. Effect estimates from NRs are raw estimates as no MAs or NMAs were performed.

Abbreviations. Adj.: adjusted; BMI: body mass index; CG: control group; CI: confidence interval; HR: hazard ratio; IG: intervention group; MA: meta-analysis; NMA: network meta-analysis; No.: number; NR: not reported; OS: observational studies; RCT: randomized controlled trial; RoB: risk of bias; RR: relative risk; SR: systematic review; T2DM: type 2 diabetes mellitus.

Two reviews assessed coronary artery disease-related outcomes in adults with BMI ≥ 35 and T2DM (Table 9).[39,42] Meta-analyses of RCTs and observational studies conducted for both reviews found that treatment with bariatric procedures reduced the risk of macrovascular complications over a wide range of follow-up (i.e., 1.8 to 20 years) compared with medical therapy (RR range, 0.43 to 0.50; $P < .01$).[39,42] Additional analyses conducted by Yan and colleagues also showed that patients treated with bariatric procedures had a statistically significant reduction in risk for any cardiovascular event (HR, 0.52 [95% CI, 0.39 to 0.71]) or MI (RR, 0.46 [0.38 to 0.55]) at 5 or more years post intervention compared with medical controls.[42]

Subgroup analyses stratified by study design (Appendix D, Table D4) found that the risk reduction in composite macrovascular complications with bariatric procedures observed for the primary analysis in Yan and colleagues (i.e., RR, 0.43) was largely informed by 3 large retrospective cohort studies (RR, 0.31 [95% CI, 0.16 to 0.62]), as between-group analyses for RCTs and prospective cohort studies were not statistically significant.[42] In contrast, all study designs demonstrated significant risk reductions in myocardial infarction with bariatric procedures compared to medical therapy.[42] Risk reduction estimates were statistically significant across study designs, and were highest in prospective cohort studies (RR, 0.35 [95% CI, 0.22 to 0.55]), followed by retrospective cohort studies (RR, 0.45 [95% CI, 0.36 to 0.56]) and RCTs (RR, 0.63 [95% CI, 0.43 to 0.93]).[42]

Other subgroup analyses by geographic region and bariatric procedure type, conducted by Hussain and colleagues, found that studies conducted in the US had larger differential risk reductions in macrovascular complications compared with non-US studies (59% vs. 29%) and that RYGB resulted in greater risk reductions than other bariatric procedures (61% vs. 45%); all between-group comparisons in subgroup analyses were significant ($P < .001$).[39]

Obstructive Sleep Apnea

We did not identify any eligible reviews of bariatric procedures that assessed improvement or resolution of obstructive sleep apnea.

Joint Arthropathy

We did not identify any eligible reviews of bariatric procedures that assessed improvement or resolution of joint arthropathy.

Intracranial Hypertension

We did not identify any eligible reviews of bariatric procedures that assessed improvement or resolution of intracranial HTN.

Quality of Life

Two SRs (1 moderate- and 1 high-RoB)[34,40] analyzed quality of life (QoL) in adults with BMIs of 35 or greater (Table 10). The reviews assessed QoL broadly in adults with severe obesity and adults with T2DM. Five-year QoL results were available for both reviews. Primary studies included in the reviews used a wide range of measurement scales to assess QoL outcomes, including general functioning scales (e.g., Short Form 36 Health Survey [SF-36]) and condition-specific scales (e.g., Gastrointestinal QoL Index [GIQLI], Impact of Weight on QoL [IWQOL]). Owing to the heterogeneity in QoL reporting, reviews opted to either standardize all QoL outcomes to a single scale (i.e., a standardized mean difference) or report results narratively.

Table 10. Quality of Life Outcomes from Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	EFFECT ESTIMATE (95% CI)	*P* VALUE
Malczak, 2021[34] High	Adults with BMI ≥ 35	GIQLI scores[a,b]	3 years	4 RCTs, 6 OS	Statistically higher QoL scores for all surgical types compared with medical therapy: ▪ AGB: MD, 17.38 (8.87 to 25.92) ▪ BPD/DS: MD, 25.8 (9.9 to 41.6) ▪ RYGB: MD, 21.4 (14.4 to 28.5) ▪ SG: MD, 20.1 (12.9 to 27.3)	NR
		GIQLI scores[a,b]	5 years	4 RCTs, 3 OS	Statistically higher QoL scores for all surgical types compared with medical therapy: ▪ BPD/DS: MD, 17.5 (12.9 to 24.2) ▪ OAGB: MD, 13.0 (8.1 to 18.0)	NR

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	EFFECT ESTIMATE (95% CI)	*P* VALUE
					■ RYGB: MD, 16.4 (12.1 to 20.7) ■ SG: MD, 11.8 (7.5 to 16.2)	
Cresci, 2020[40] Moderate	Patients with BMI ≥ 35 and T2DM	QOL (various scales)	1 year	1 RCT	■ Improvements in overall QOL (EQ5D scale) noted in both groups (RYGB vs. medical controls) ■ No significant between-group difference in scores	NR
			3 years	1 RCT	■ Improvements in overall (SF-36) and diabetes-related QOL (PAID) noted in both groups; no significant between-group difference in scores ■ Superior weight-related QoL scores (IWQoL) among participants with RYGB vs. controls	NR
			5 years	3 RCTs	■ Superior SF-36 scores among participants with surgery (i.e., AGB, BPD/DS, RYGB) vs. controls	NR

Notes. Between-group *P* values not reported for any available QoL analysis. [a] To pool data from different QoL forms, SMDs were used for overall QOL and then converted to GIQLI scale scores. [b] GIQLI score range: 0 to 144; higher scores indicate better GIQLI, with a clinically meaningful difference of > 5 points.

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BPD/DS: biliopancreatic diversion with duodenal switch; CI: confidence interval; EQ5D: European QoL questionnaire; GIQLI: Gastrointestinal QoL Index; IWQoL: Impact of Weight on QoL questionnaire; MD: mean difference; No.: number; NR: not reported; OAGB: one anastomosis gastric bypass; OS: observational study; PAID: Problem Areas in Diabetes; QoL: quality of life; RCT: randomized controlled trial; ROB: risk of bias; RYGB: Roux-en-Y gastric bypass; SF-36: short form 36; SG: sleeve gastrectomy; SMD: standardized mean difference; T2DM: type 2 diabetes mellitus.

In their 2021 SR, Malczak and colleagues conducted NMAs of mixed study designs to assess 3-year (4 RCTs and 6 comparative cohort studies) and 5-year (4 RCTs and 3 comparative cohort studies) differences in QoL between patients with severe obesity who underwent bariatric procedures compared with those who received nonsurgical lifestyle interventions.[34] To pool data from different QoL scales, review authors compared standardized mean differences (SMDs) of overall QOL scores between groups and then converted the results into a single GIQLI.[34] After 3 years of follow-up, patients who received AGB, BPD/DS, laparoscopic RYGB, and SG reported significantly greater improvements in overall health-related QoL mean scores (SMD range, 0.78 to 1.16) corresponding with clinically significant differential improvements (i.e., > 5 points on the GIQLI scale) in gastrointestinal QoL (range, 17.4 to 25.8 points) compared with nonsurgical controls (Table 10).[34] Only 1 procedure type included in the 3-year analysis, the banded RYGB, was not associated with comparatively greater QoL.[34] Results at 5 years were similar, with patients who received any bariatric procedure (i.e., BPD/DS, OAGB, RYGB, SG) reporting significantly greater improvements in overall QoL (SMD range, 0.92 to 1.43) and gastrointestinal QoL (range, 11.8 to 17.5 points) compared with nonsurgical controls (Table 10).[34] The clinical implications of these results are unclear given variation in QoL measures, study designs, statistical methodology, and study quality.

Adults with BMI ≥ 35 and T2DM

In a systematic review conducted by Cresci and colleagues comparing the effectiveness of bariatric procedures with nonsurgical management for patients with T2DM, QoL results from 5 RCTs were narratively summarized.[40] In general, studies showed that there were few between-group differences in overall or condition-specific QoL in the short-term (i.e., 1 to 3 years post randomization), whereas patients with T2DM randomized to bariatric procedures reported significantly higher overall QoL scores after 5 years compared with nonsurgical controls (Table 10).[40]

Harms

Six low- to high-RoB reviews[16,35,40,43,44,46,48,51] assessed harms outcomes in adults with BMI of 35 or greater (Table 11; Appendix D, Table D3). Reviews reported a range of harms including deaths, surgical complications, surgical revisions and reoperations, vitamin deficiencies, overall serious adverse events, and specific adverse events, such as fractures. As compared with other outcomes assessed in this evidence review, harms reporting in the primary studies was less robust, particularly for longer-term outcomes, which may have resulted in the underestimation of complications.

Table 11. Harms Outcomes from Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	EFFECT ESTIMATE[a] (95% CI)	*P* VALUE
Ablett, 2019[44] Moderate	Adults with BMI ≥ 35	Bone fractures (any type)	1 to 2 years	3 RCTs	IG: 8 of 226 CG: 5 of 139 RR, 0.82 (0.29 to 2.35)	*P* = .72
			2.2 to 8.9 years	6 OS	4 studies reported a significantly increased risk of fracture with surgery vs. medical therapy: HR range, 1.21 (1.01 to 1.44) to 2.3 (1.8 to 2.8) 2 studies found no difference in the risk of fracture between groups	NR
Arterburn, 2020[16] High	Adults with BMI ≥ 35	Reoperations	5 years	2 RCTs 5 OS	Overall: 5% to 22.1% RCTs: 8.3% to 22.1% OS: 5% to 22.1%	NR
			10 years	9 studies	Overall: 8% to 64% RYGB (7 studies): 8% to 64% (median 29%) SG (2 studies): 32% to 36%	
Cresci, 2020[40] Moderate	Adults with BMI ≥ 35 and T2DM	Serious adverse events		10 RCTs	IG: 72 of 386 CG: 44 of 337 HR, 1.44 (0.66 to 3.16)	*P* = .36
		Death		10 RCTs	IG: 0 of 386 CG: 3 of 337 HR, 0.21 (0.03 to 1.32)	*P* = .10
		Severe hypoglycemia		10 RCTs	IG: 4 of 386 CG: 4 of 337 HR, 0.69 (0.19 to 2.52)	*P* = .58
		Revisions		10 RCTs	4 of 386	
Park, 2019[43] Low	Adults with BMI ≥ 40	Death	1 to 5 years	45 RCTs	ABG: no deaths BPD/DS: no deaths RYGB: 2 deaths (mortality rate: 0.1%) SG: no deaths VBG: 2 deaths (mortality rate: 2.0%)	NR
		Surgical complications	1 to 5 years	45 RCTs	Hernia: 0.6% to 5.1% Obstruction/stricture: 0.8% to 4.0% GI bleeding: 0.8% to 3.5% Leakage/perforation: 0.7% to 3.5% Wound infection: 0.3% to 1.8% Ulcer: 0.2% to 1.5%	NR

AUTHOR, YEAR ROB	REVIEW POPULATION	OUTCOME TYPE	FOLLOW-UP	NO. OF STUDIES	EFFECT ESTIMATE[a] (95% CI)	*P* VALUE
					Dumping syndrome: 0.2% to 0.7% Hemoperitoneum: 0.1% (RYGB only)	
Robertson, 2020[35] High	Adults with BMI ≥ 35	Surgical complications (perioperative mortality rate)	90 days	58 OS	4,707 of 3,650,961 Rate: 0.08 (0.06 to 0.10)	NR
Wang, 2021[37] Low	Adults with BMI ≥ 35	Adverse events	1 to 10 years	19 RCTs	IG: 603 events (0.28 per person/year) CG: 393 events (0.23 per person/year)	NR
		Deaths	1 to 10 years	19 RCTs	IG: 2 deaths (1 after CABG surgery; 1 cause not reported) CG: 2 deaths (fatal MIs)	NR

Note. [a] Unless otherwise noted, effect estimates for SRs represent between-group comparisons for bariatric procedures vs. medical therapy controls. Effect estimates from NRs are raw estimates as no MAs or NMAs were performed.

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BPD/DS: biliopancreatic diversion with duodenal switch; CABG: coronary artery bypass graft; CG: control group; CI: confidence interval; GI: gastrointestinal; HR: hazard ratio; IG: intervention group; MA: meta-analysis; MI: myocardial infarction; NMA: network meta-analysis; No.: number; NR: not reported; OS: observational studies; RCT: randomized controlled trial; ROB: risk of bias; RR: relative risk or risk ratio; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; SR: systematic review; T2DM: type 2 diabetes mellitus; VBG: vertical banded gastroplasty.

Six reviews reported on harms in adults with BMI 35 kg/m^2 or greater (Table 11; Appendix D, Table D3).[16,35,40,43,44,51]

Three reviews included at least 22 RCTs and 6 observational studies comparing the rates of adverse events for bariatric procedures versus medical therapy over 1 to 10 years of follow-up.[40,44,51] Across the reviews, no between-group differences were observed in the overall rate of adverse events,[51] serious adverse events,[40] severe hypoglycemia events,[51] or death.[40,51] One review that assessed the risk of bone fractures as a proxy measure for vitamin deficiencies observed no short-term difference in 3 RCTs; however, 4 of 6 observational studies with longer-term follow-up observed a statistically significant higher risk of bone fractures of any type or site with bariatric procedures than medical therapy (HR range, 1.21 to 2.3).[44]

Two reviews assessed complications and mortality in the perioperative period (i.e., 90 days postsurgery). In one review of 45 RCTs, overall rates of reported surgical complications were low, ranging from 0.1% to 5.1%.[43] Common complications included hernia, obstructions or structures, gastrointestinal bleeding, leaking or perforation at the surgical site, wound infections, ulcers, and dumping syndrome.[43] The most common complications for each included procedure were hernias with RYGB (5.1%), obstruction or stricture with SG (1.2%), bleeding or leakage with BPD/DS (3.5%), and obstruction or leakage with AGB (0.8%). In terms of mortality, an analysis of 58 observational studies that included over 3.5 million participants found that the pooled rate of perioperative mortality up to 90 days post-surgery was less than 0.1% (rate, 0.08 [95% CI, 0.06 to 0.10]).[35] Subgroup analyses showed that the rate of perioperative mortality did not vary significantly by follow-up period (i.e., in-hospital, 30 days, 90 days) or study type, but was significantly higher with BPD/DS (rate, 0.41 [95% CI, 0.25 to 0.60]) compared to other bariatric procedures.

Two reviews reported on rates of surgical revisions or reoperations following bariatric procedures.[16,40] Across 10 RCTs and 1 to 5 years of follow-up, Cresci and colleagues identified 4 instances of surgical revisions (among 386 patients) but did not specify which bariatric procedure types required revisions or give detail about the type or extent of revision required.[40] A narrative review reported rates of reoperations ranging from 5% to 22% at 5 years of follow-up and from 8% to 64% at 10 years of follow-up, suggesting an increasing need for surgical reintervention in the long-term.[16] In cohort studies, rates of reoperations were significantly lower with SG compared to RYBG (HR range, 0.72 to 0.80), but there was no significant difference in rates reported in RCTs.[16]

Ongoing Studies

One recent publication described ongoing RCTs for bariatric procedures worldwide including studies representing populations on 6 continents based on a map of registered trials.[52] The authors identified 62 ongoing RCTs with a combined total of 10,800 planned participants.[52] Most of the studies plan to investigate the effectiveness of bariatric procedures for treating other chronic conditions related to obesity (e.g., type 2 diabetes, HTN), improving QoL, increasing weight loss, and collecting information about surgical complications.[52] More than half of the studies plan to have at least a 12-month follow-up after the procedure, and about a quarter plan to follow up 4 years after the procedure.[52] The most common procedures included in the trials are RYGB and SG, and more recent surgical procedures are included in fewer trials, but are still represented (e.g., SADI-S in 8.1%). [52] Some of the trials include participants with BMI as low as 25 to 30.[52] None of the identified RCTs enrolled participants younger than 18 years of age.[52]

Adults with BMI 30.0 to 34.9 kg/m^2

We identified 6 eligible RCTs (N = 596) that compared bariatric surgery with medical therapy for the treatment of obesity management in adults with BMIs between 30 and 34.9 (Table 12).[53-58] Although not a criterion for inclusion, all eligible trials in this population were only conducted among individuals with T2DM. Study samples sizes ranged from 57 to 150 participants and included study follow-up ranging from 1 to 5 years. A majority of RCTs included US study sites; non-US study sites were located in Brazil, China, and Taiwan. Most studies compared RYGB with a range of medical therapies including both lifestyle interventions and pharmacotherapy. See Appendix D Table D5 for details regarding study inclusion criteria and additional participant characteristics.

Two included trials had populations with mean baseline BMIs that exceeded the upper limit (i.e., BMI 34.9).[54,58] Most participants in the Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes (TRIABETES) study[54] had BMIs within the target range (i.e., BMI 30 to 34.9), so full study results are reported. In contrast, adults with BMI in the target range accounted for only about a third of participants in the Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently (STAMPEDE) trial[58]; therefore, we limited results to subgroup analyses of participants with BMI less than 35.

It should also be noted that several otherwise eligible trials comparing surgery to medical therapy in this population were excluded as they solely assessed AGB, which is of limited relevance to current clinical practice.

Table 12. Characteristics of Included Trials of Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME RISK OF BIAS	STUDY POPULATION	TOTAL SAMPLE MAX FOLLOW-UP COUNTRY	STUDY GROUP	N, GROUP	AGE (YEARS)	BMI (kg/m^2)
Cohen, 2020[53] MOMS Moderate	Adults with BMI 30 to 35, T2DM, and early-stage kidney disease	N = 100 2 years Brazil	RYGB	N = 51	52.5 (7.6)	32.5 (1.9)
			MT	N = 49	50.2 (7.5)	32.6 (2.1)
Courcoulas, 2014[54] TRIABETES Moderate	Adults with Grade I or II obesity and T2DM	N = 61 5 years United States	RYGB	N = 20	46.3 (7.2)	35.5 (2.6)
			MT	N = 20	48.3 (4.7)	35.7 (3.3)
Ikramuddin, 2013[55] DSS Low	Adults with BMI 30.0 to 39.9 and T2DM for at least 6 months	N = 120 5 years United States and Taiwan	RYGB	N = 60	49.0 (9.0)	34.9 (3.0)
			MT	N = 60	49.0 (8.0)	34.3 (3.1)
Liang, 2013[56] Moderate	Obese adults with T2DM and hypertension	N = 108 1 year China	RYGB	N = 31	50.8 (5.4)	30.5 (0.9)
			MT	N = 36	51.8 (6.7)	30.3 (2.0)
Parikh, 2014[57,58] Moderate	Adults with BMI 30 to 35 and T2DM who otherwise met NIH bariatric surgery criteria	N = 57 5 years United States	Surgery (RYGB, SG, or AGB)	N = 29	46.8 (8.1)	32.8 (1.7)
			MT	N = 28	53.9 (8.4)	32.4 (1.8)
Schauer, 2012 STAMPEDE[a] Low	Obese adults with poorly controlled T2DM	N = 150 5 years United States	RYGB	N = 50	48.3 (8.4)	37.0 (3.3) BMI < 35: 14 of 50 (28%)
			SG	N = 50	47.9 (8.0)	36.2 (3.9) BMI < 35: 18 of 50 (36%)
			MT	N = 50	49.7 (7.4)	36.8 (3.0) BMI < 35: 19 of 50 (38%)

Notes. [a] Reported results from STAMPEDE are limited to subgroup analyses of participants with BMI < 35.
Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; DSS: diabetes surgery study; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; NIH: National Institutes of Health; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; STAMPEDE: Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently; T2DM: type 2 diabetes mellitus; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

All-cause Mortality

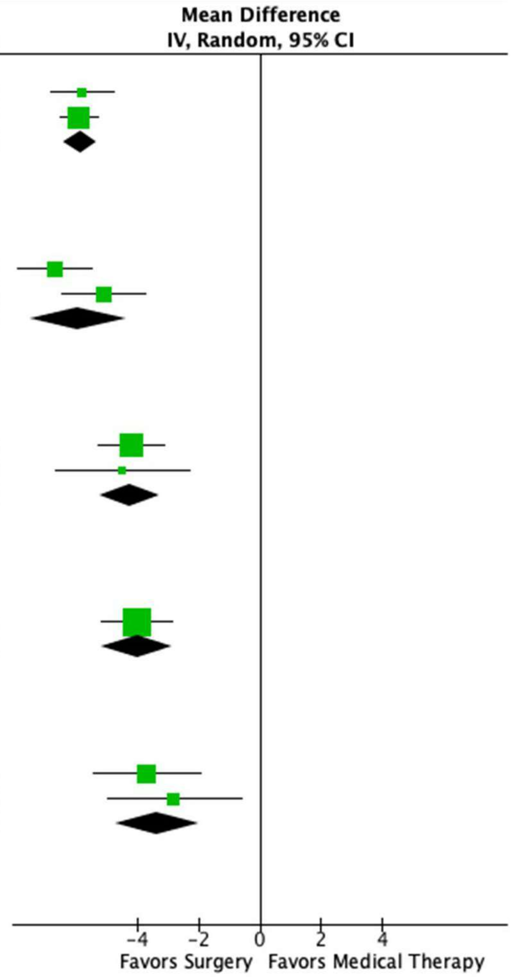
We did not identify any eligible reviews of bariatric procedures that estimated all-cause mortality in adults with BMI 30.0 to 34.9 and T2DM.

Weight Change

Weight change outcomes were reported in all included trials of adults with BMI 30 to 34.9 except for the STAMPEDE study. Weight change was primarily assessed as a factor of mean BMI change (Figure 1) and percentage change in total body weight (Figure 2); additional weight loss outcomes (e.g., mean weight, % excess weight loss) and subgroup data are detailed in Appendix D, Table D6.

Figure 1. Mean BMI (kg/m^2) at 1 to 5 years Follow-up in Adults with BMI 30 to 34.9

Study or Subgroup	Surgery Mean	Surgery SD	Surgery Total	Medical Therapy Mean	Medical Therapy SD	Medical Therapy Total	Weight	Mean Difference IV, Random, 95% CI
1.1.1 1 year								
Ikramuddin 2013 (DSS)	25.8	2.6	57	31.6	3	57	27.8%	-5.80 [-6.83, -4.77]
Liang 2013	24.5	0.9	31	30.4	1.7	36	72.2%	-5.90 [-6.54, -5.26]
Subtotal (95% CI)			**88**			**93**	**100.0%**	**-5.87 [-6.42, -5.33]**
Heterogeneity: Tau² = 0.00; Chi² = 0.03, df = 1 (P = 0.87); I² = 0%								
Test for overall effect: Z = 21.18 (P < 0.00001)								
1.1.2 2 years								
Cohen 2020 (MOMS)	24.5	3.6	51	31.2	2.4	49	52.5%	-6.70 [-7.89, -5.51]
Ikramuddin 2013 (DSS)	26.8	4.1	56	31.9	3.3	54	47.5%	-5.10 [-6.49, -3.71]
Subtotal (95% CI)			**107**			**103**	**100.0%**	**-5.94 [-7.51, -4.37]**
Heterogeneity: Tau² = 0.84; Chi² = 2.93, df = 1 (P = 0.09); I² = 66%								
Test for overall effect: Z = 7.44 (P < 0.00001)								
1.1.3 3 years								
Ikramuddin 2013 (DSS)	27.3	2.9	55	31.5	2.7	46	80.1%	-4.20 [-5.29, -3.11]
Parikh 2014	26.6	3.1	29	31.1	3.6	14	19.9%	-4.50 [-6.70, -2.30]
Subtotal (95% CI)			**84**			**60**	**100.0%**	**-4.26 [-5.24, -3.28]**
Heterogeneity: Tau² = 0.00; Chi² = 0.06, df = 1 (P = 0.81); I² = 0%								
Test for overall effect: Z = 8.53 (P < 0.00001)								
1.1.4 4 years								
Ikramuddin 2013 (DSS)	27.5	2.9	55	31.5	3	46	100.0%	-4.00 [-5.16, -2.84]
Subtotal (95% CI)			**55**			**46**	**100.0%**	**-4.00 [-5.16, -2.84]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 6.78 (P < 0.00001)								
1.1.5 5 years								
Ikramuddin 2013 (DSS)	27.4	3.9	55	31.1	4.7	43	61.4%	-3.70 [-5.44, -1.96]
Parikh 2014	25.8	3.1	29	28.6	3.6	14	38.6%	-2.80 [-5.00, -0.60]
Subtotal (95% CI)			**84**			**57**	**100.0%**	**-3.35 [-4.72, -1.99]**
Heterogeneity: Tau² = 0.00; Chi² = 0.40, df = 1 (P = 0.53); I² = 0%								
Test for overall effect: Z = 4.81 (P < 0.00001)								



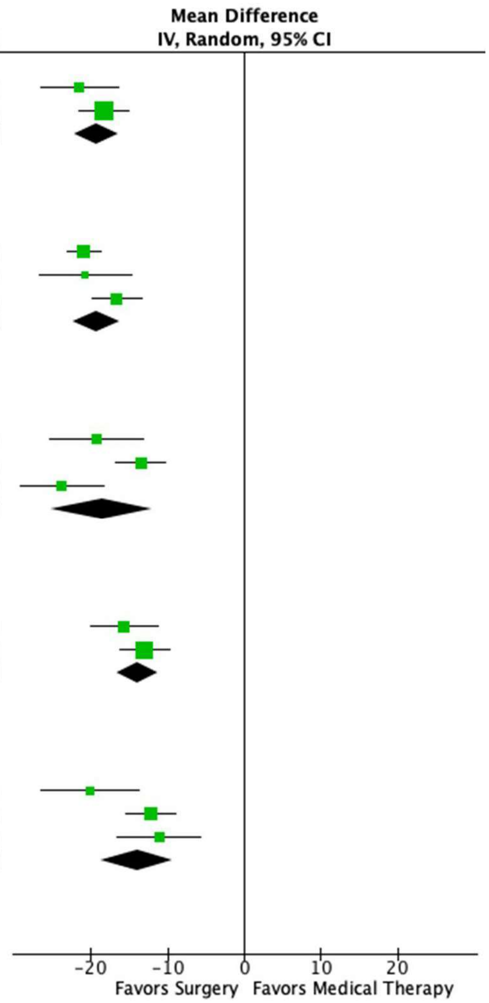
Test for subgroup differences: Chi² = 21.40, df = 4 (P = 0.0003), I² = 81.3%

Note. Forest plot generated using Review Manager (RevMan) software, version 5.4

Abbreviations. BMI: body mass index; CI: confidence interval; DSS: diabetes surgery study; IV: inverse variance; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; SD: standard deviation.

Figure 2. Percent Weight Change in Adults with BMI 30 to 34.9

Study or Subgroup	Surgery Mean	Surgery SD	Surgery Total	Medical Therapy Mean	Medical Therapy SD	Medical Therapy Total	Weight	Mean Difference IV, Random, 95% CI
1.2.1 1 year								
Courcoulas 2014 (TRIABETES)	−29.1	7.8	24	−7.6	9.6	23	31.0%	−21.50 [−26.51, −16.49]
Ikramuddin 2013 (DSS)	−26.1	8.7	57	−7.8	8.7	57	69.0%	−18.30 [−21.49, −15.11]
Subtotal (95% CI)			**81**			**80**	**100.0%**	**−19.29 [−22.19, −16.39]**
Heterogeneity: Tau² = 0.52; Chi² = 1.11, df = 1 (P = 0.29); I² = 10%								
Test for overall effect: Z = 13.03 (P < 0.00001)								
1.2.2 2 years								
Cohen 2020 (MOMS)	−25.4	5.3	51	−4.5	5.6	49	45.4%	−20.90 [−23.04, −18.76]
Courcoulas 2014 (TRIABETES)	−26.3	8.5	18	−5.6	8.6	14	18.5%	−20.70 [−26.68, −14.72]
Ikramuddin 2013 (DSS)	−23.9	8.6	56	−7.3	8.4	54	36.1%	−16.60 [−19.78, −13.42]
Subtotal (95% CI)			**125**			**117**	**100.0%**	**−19.31 [−22.43, −16.19]**
Heterogeneity: Tau² = 4.38; Chi² = 4.97, df = 2 (P = 0.08); I² = 60%								
Test for overall effect: Z = 12.15 (P < 0.00001)								
1.2.3 3 years								
Courcoulas 2014 (TRIABETES)	−25	8.5	18	−5.7	9	14	30.3%	−19.30 [−25.44, −13.16]
Ikramuddin 2013 (DSS)	−22	8.5	55	−8.5	8.1	46	37.4%	−13.50 [−16.74, −10.26]
Parikh 2014	−26.6	9.4	30	−2.8	8.1	14	32.2%	−23.80 [−29.21, −18.39]
Subtotal (95% CI)			**103**			**74**	**100.0%**	**−18.58 [−25.17, −11.99]**
Heterogeneity: Tau² = 27.43; Chi² = 11.03, df = 2 (P = 0.004); I² = 82%								
Test for overall effect: Z = 5.53 (P < 0.00001)								
1.2.4 4 years								
Courcoulas 2014 (TRIABETES)	−24.1	9.4	20	−8.4	3.6	20	35.2%	−15.70 [−20.11, −11.29]
Ikramuddin 2013 (DSS)	−21.7	8.5	55	−8.7	8.3	48	64.8%	−13.00 [−16.25, −9.75]
Subtotal (95% CI)			**75**			**68**	**100.0%**	**−13.95 [−16.57, −11.33]**
Heterogeneity: Tau² = 0.00; Chi² = 0.93, df = 1 (P = 0.33); I² = 0%								
Test for overall effect: Z = 10.45 (P < 0.00001)								
1.2.5 5 years								
Courcoulas 2014 (TRIABETES)	−25.2	9.4	20	−5.1	11.2	20	26.6%	−20.10 [−26.51, −13.69]
Ikramuddin 2013 (DSS)	−21.8	8.5	55	−9.6	7.8	43	42.5%	−12.20 [−15.44, −8.96]
Parikh 2014	−21.4	9.4	29	−10.3	8.1	14	30.9%	−11.10 [−16.55, −5.65]
Subtotal (95% CI)			**104**			**77**	**100.0%**	**−13.96 [−18.64, −9.29]**
Heterogeneity: Tau² = 10.65; Chi² = 5.39, df = 2 (P = 0.07); I² = 63%								
Test for overall effect: Z = 5.86 (P < 0.00001)								
Test for subgroup differences: Chi² = 11.56, df = 4 (P = 0.02), I² = 65.4%								



Note. Forest plot generated using Review Manager (RevMan) software, version 5.4
Abbreviations. BMI: body mass index; CI: confidence interval; DSS: diabetes surgery study; IV: inverse variance; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; SD: standard deviation; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Results from our pooled analyses of weight change data showed that adults with T2DM and BMI 30 to 34.9 who underwent bariatric procedures experienced significantly more weight loss compared with those who received medical therapy, as evidenced by statistically significant between-groups differences in mean BMI ranging from -5.9 to -3.4 kg/m^2 (P < .001) over 1 to 5 years of follow-up (Figure 1).[53,55-57] The TRIABETES study was excluded from the BMI meta-analysis since mean follow-up values were not reported; however, the bariatric surgery group experienced a mean BMI reduction of -8.6 kg/m^2 from baseline to 5 years compared with -1.2 kg/m^2 in the control group (P < .001), which aligns with the pooled 5-year results (Appendix D, Table D6).[54]

Notably, all bariatric surgery groups included in the pooled analyses achieved mean BMIs below the minimum obesity threshold (30 kg/m^2) at all follow-up timepoints (BMI Range, 24.5 to 27.5), whereas the majority of medical therapy groups continued to have mean BMIs > 30 (BMI Range, 28.6 to 31.5).[53,55-57] Moreover, 51% (N = 26) of participants who received bariatric surgery in the Microvascular Outcomes after Metabolic Surgery (MOMS) study achieved a BMI in the normal range (i.e., 18.5 to 24.9) at the 2-year follow-up compared with none in the medical therapy group ($P < .001$; Appendix D, Table D6).[53]

Across the 5 years of available follow-up, our pooled analyses additionally showed that bariatric surgery recipients experienced 14 to 20% greater weight loss compared with medical therapy recipients ($P < .001$), corresponding with mean percent weight loss of around 20 to 30% in bariatric surgery groups versus 5 to 10% in medical therapy groups (Figure 2).[53-57] Additional analyses reported in the MOMS study showed that 95% (N = 49) of participants who received bariatric surgery lost 15% or more of their body weight compared with only 5% (N = 2) in the medical therapy group ($P < .001$; Appendix D, Table D6).[53] Taken together, meta-analyses of mean BMI and percent weight loss data suggest that bariatric surgery results in significant and sustained differential weight loss compared with medical therapy in adults with T2DM and BMI 30 to 34.9.

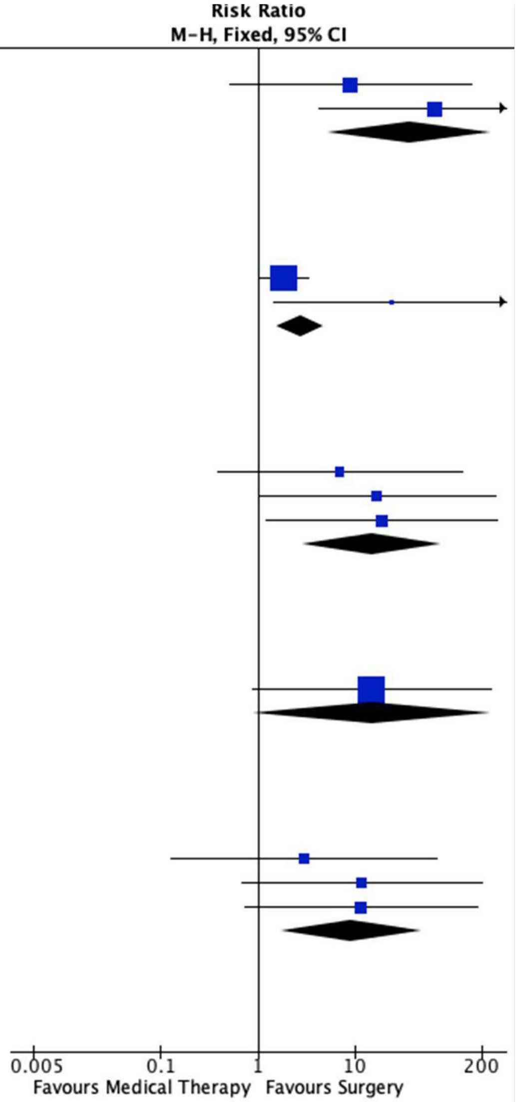
Change in Chronic Disease Status

Diabetes

All participants in bariatric surgery trials of adults with BMI 30 to 34.9 were required to have a diagnosis of T2DM at baseline to qualify for enrollment. As such, some form of T2DM remission or improvement was reported in all included trials. In these studies, changes in T2DM status were evaluated as dichotomous measures of proportion achieving remission (Figure 3) or as continuous differences in mean HbA1c at follow-up (Figure 4). As with the adult population with BMI >35, definitions used for T2DM remission varied in terms of the nominal HbA1c remission threshold (5.7% vs. 6.5% vs. 6.0%) and whether remission required cessation of diabetic medication use or additional reductions in fasting plasma glucose. To facilitate direct comparison when multiple HbA1c remission thresholds were reported, we analyzed results for those closest to the 6.5% remission threshold endorsed by the American Diabetes Association in 2021.[59] Additional T2DM-related outcomes and subgroup data are detailed in Appendix D, Table D7.

Figure 3. T2DM Remission in Adults with BMI 30 to 34.9

Study or Subgroup	Surgery Events	Surgery Total	Medical Therapy Events	Medical Therapy Total	Weight	Risk Ratio M-H, Fixed, 95% CI
2.1.1 1 year						
Courcoulas 2014 (TRIABETES)	4	20	0	20	51.9%	9.00 [0.52, 156.91]
Liang 2013	28	31	0	36	48.1%	65.91 [4.19, 1036.83]
Subtotal (95% CI)		**51**		**56**	**100.0%**	**36.38 [5.28, 250.94]**
Total events	32		0			
Heterogeneity: Chi² = 1.10, df = 1 (P = 0.30); I² = 9%						
Test for overall effect: Z = 3.65 (P = 0.0003)						
2.1.2 2 years						
Cohen 2020 (MOMS)	23	51	12	49	96.0%	1.84 [1.03, 3.28]
Ikramuddin 2013 (DSS)	12	56	0	54	4.0%	24.12 [1.46, 397.61]
Subtotal (95% CI)		**107**		**103**	**100.0%**	**2.73 [1.55, 4.80]**
Total events	35		12			
Heterogeneity: Chi² = 4.11, df = 1 (P = 0.04); I² = 76%						
Test for overall effect: Z = 3.49 (P = 0.0005)						
2.1.3 3 years						
Courcoulas 2014 (TRIABETES)	3	20	0	20	28.9%	7.00 [0.38, 127.32]
Ikramuddin 2013 (DSS)	10	55	0	44	32.1%	16.88 [1.02, 280.23]
Parikh 2014	19	30	0	14	39.0%	18.87 [1.22, 291.84]
Subtotal (95% CI)		**105**		**78**	**100.0%**	**14.80 [2.85, 76.85]**
Total events	32		0			
Heterogeneity: Chi² = 0.29, df = 2 (P = 0.86); I² = 0%						
Test for overall effect: Z = 3.21 (P = 0.001)						
2.1.4 4 years						
Ikramuddin 2013 (DSS)	9	54	0	42	100.0%	14.85 [0.89, 248.14]
Subtotal (95% CI)		**54**		**42**	**100.0%**	**14.85 [0.89, 248.14]**
Total events	9		0			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.88 (P = 0.06)						
2.1.5 5 years						
Courcoulas 2014 (TRIABETES)	1	20	0	20	29.0%	3.00 [0.13, 69.52]
Ikramuddin 2013 (DSS)	7	55	0	43	32.4%	11.79 [0.69, 200.79]
Parikh 2014	11	29	0	14	38.6%	11.50 [0.73, 182.20]
Subtotal (95% CI)		**104**		**77**	**100.0%**	**9.13 [1.71, 48.62]**
Total events	19		0			
Heterogeneity: Chi² = 0.54, df = 2 (P = 0.76); I² = 0%						
Test for overall effect: Z = 2.59 (P = 0.010)						



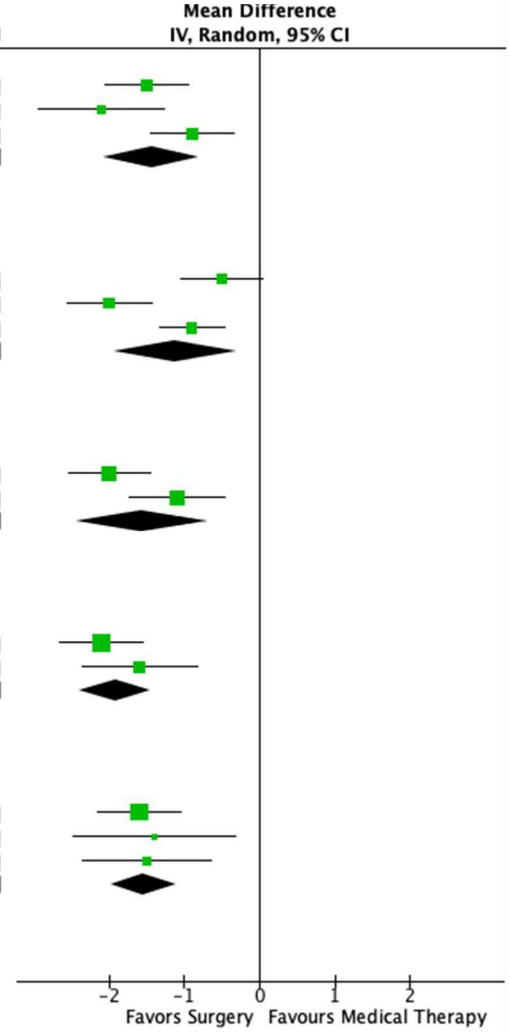
Test for subgroup differences: Chi² = 10.87, df = 4 (P = 0.03), I² = 63.2%

Note. Forest plot generated using Review Manager (RevMan) software, version 5.4

Abbreviations. BMI: body mass index; CI: confidence interval; DSS: diabetes surgery study; MOMS: Microvascular Outcomes after Metabolic Surgery; M-H: Mantel-Haenszel test; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Figure 4. Mean HbA1c (%) in Adults with BMI 30 to 34.9

Study or Subgroup	Surgery Mean	Surgery SD	Surgery Total	Medical Therapy Mean	Medical Therapy SD	Medical Therapy Total	Weight	Mean Difference IV, Random, 95% CI
2.2.1 1 year								
Ikramuddin 2013 (DSS)	6.3	1.5	57	7.8	1.5	57	36.6%	−1.50 [−2.05, −0.95]
Liang 2013	6	1.7	31	8.1	1.8	36	26.7%	−2.10 [−2.94, −1.26]
Schauer 2012 (STAMPEDE)	6.6	0.8	32	7.5	1	17	36.6%	−0.90 [−1.45, −0.35]
Subtotal (95% CI)			**120**			**110**	**100.0%**	**−1.44 [−2.07, −0.81]**
Heterogeneity: Tau² = 0.20; Chi² = 5.92, df = 2 (P = 0.05); I² = 66%								
Test for overall effect: Z = 4.49 (P < 0.00001)								
2.2.2 2 years								
Cohen 2020 (MOMS)	6.2	1.4	51	6.7	1.4	49	32.8%	−0.50 [−1.05, 0.05]
Ikramuddin 2013 (DSS)	6.4	1.5	56	8.4	1.5	54	32.6%	−2.00 [−2.56, −1.44]
Schauer 2012 (STAMPEDE)	6.8	0.6	32	7.7	0.8	17	34.7%	−0.90 [−1.33, −0.47]
Subtotal (95% CI)			**139**			**120**	**100.0%**	**−1.13 [−1.94, −0.31]**
Heterogeneity: Tau² = 0.45; Chi² = 15.29, df = 2 (P = 0.0005); I² = 87%								
Test for overall effect: Z = 2.70 (P = 0.007)								
2.2.3 3 years								
Ikramuddin 2013 (DSS)	6.7	1.5	56	8.7	1.3	46	51.7%	−2.00 [−2.54, −1.46]
Schauer 2012 (STAMPEDE)	7.1	0.8	32	8.2	1.2	17	48.3%	−1.10 [−1.73, −0.47]
Subtotal (95% CI)			**88**			**63**	**100.0%**	**−1.57 [−2.45, −0.68]**
Heterogeneity: Tau² = 0.31; Chi² = 4.46, df = 1 (P = 0.03); I² = 78%								
Test for overall effect: Z = 3.48 (P = 0.0005)								
2.2.4 4 years								
Ikramuddin 2013 (DSS)	7	1.5	55	9.1	1.3	43	64.6%	−2.10 [−2.66, −1.54]
Schauer 2012 (STAMPEDE)	7.2	1.1	32	8.8	1.4	17	35.4%	−1.60 [−2.37, −0.83]
Subtotal (95% CI)			**87**			**60**	**100.0%**	**−1.92 [−2.39, −1.45]**
Heterogeneity: Tau² = 0.01; Chi² = 1.07, df = 1 (P = 0.30); I² = 7%								
Test for overall effect: Z = 8.04 (P < 0.00001)								
2.2.5 5 years								
Ikramuddin 2013 (DSS)	7.1	1.5	55	8.7	1.3	43	59.2%	−1.60 [−2.16, −1.04]
Parikh 2014	6.9	1.4	27	8.3	1.8	14	15.6%	−1.40 [−2.48, −0.32]
Schauer 2012 (STAMPEDE)	7.3	1.1	32	8.8	1.6	17	25.2%	−1.50 [−2.35, −0.65]
Subtotal (95% CI)			**114**			**74**	**100.0%**	**−1.54 [−1.97, −1.12]**
Heterogeneity: Tau² = 0.00; Chi² = 0.12, df = 2 (P = 0.94); I² = 0%								
Test for overall effect: Z = 7.08 (P < 0.00001)								
Test for subgroup differences: Chi² = 3.43, df = 4 (P = 0.49), I² = 0%								



Note. Forest plot generated using Review Manager (RevMan) software, version 5.4

Abbreviations. BMI: body mass index; CI: confidence interval; DSS: diabetes surgery study; IV: inverse variance; MOMS: Microvascular Outcomes after Metabolic Surgery; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Across 1 to 5 years of available trial follow-up, bariatric surgery was associated with significant differential improvements in T2DM compared with medical therapy in adults with BMI 30 to 34.9.[53-58] Meta-analyses of T2DM remission rates showed that, apart from year 4, bariatric surgery groups were significantly more likely than medical therapy groups (RR range, 2.7 to 36.4) to achieve remission at both short- and long-term follow-up (Figure 3).[53-57] Confidence intervals in the pooled analyses were relatively wide owing to the low rate of observed remission events in the control groups. At maximum study follow-up, the rate of remission in bariatric surgery groups ranged from 16 to 90% versus 0 to 50% in the medical therapy groups (Appendix D, Table D7).[53-57] The wide range of estimates was likely influenced by differences in remission definitions between trials. To that end, analyses of diabetes medication use reported in 4 trials (a component of several remission definitions) indicated that participants who received bariatric surgery were significantly less likely than those who received medical therapy to report continued use of insulin or noninsulin T2DM medications (e.g., metformin) at 2 to 5 years follow-up (Table 13).[53-55,57]

Table 13. T2DM-Related Medication Use in Studies of Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME	FOLLOW-UP	OUTCOME	MEDICATION USE RATES	*P* VALUE
Cohen, 2020[53] MOMS	2 years	Insulin use	RYGB: 5 of 46 (11%) MT: 25 of 46 (54%)	$P < .001$
		Metformin use	RYGB: 35 of 46 (76%) MT: 45 of 46 (98%)	$P = .004$
Courcoulas, 2014[54] TRIABETES	5 years	Insulin or noninsulin T2DM medication use	RYGB: 7 of 16 (44%) MT: 14 of 14 (100%)	$P < .001$
Ikramuddin, 2013[55] DSS	5 years	Insulin use	RYGB: 9 of 60 (15%) MT: 22 of 60 (37%)	$P = .02$
		Non-insulin T2DM medication use	RYGB: 25 of 60 (42%) MT: 53 of 60 (88%)	$P < .001$
Parikh, 2014[57]	5 years	Insulin use	Surg: 3 of 29 (10%) MT: 7 of 14 (50%)	$P = .007$

Abbreviations. BMI: body mass index; DSS: diabetes surgery study; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; RYGB: Roux-en-Y gastric bypass; Surg: bariatric surgery, any type; T2DM: type 2 diabetes mellitus; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Pooled analyses, presented in Figure 4, also showed that mean HbA1c was significantly lower among participants randomized to bariatric procedures compared with medical therapy across 1 to 5 years of follow-up (MD range, -1.1% to -1.9%; $P < .01$).[53,55-58] Across all years of reported follow-up, mean HbA1c ranged from 6.0 to 7.2% in the intervention groups compared with 6.7 to 9.1% in the control groups; however, no study groups had a mean HbA1c below the American Diabetes Association remission threshold of 6.5% after 2 years.[53,55-58] Almost all surgical participants in the contributing trials received RYGB; however, subgroup analyses by procedure type conducted by Parikh and colleagues did not find any differences in mean HbA1c values at 5 years ($P = .61$) when comparing RYGB, SG, and AGB.[57]

Hypertension

HTN-related outcomes were available for adults with BMI 30 to 34.9 in all included trials except for STAMPEDE. HTN remission, when reported, was generally measured by achievement of certain blood pressure (BP) targets (i.e., systolic BP < 130 mmHg and diastolic BP < 80 mmHg) or the cessation of antihypertensive medications at follow-up (Table 14). However, most trials only compared intermediate HTN indicators, such as mean systolic and diastolic BP, between groups at follow-up (Figures 5 and 6, respectively).

Table 14. Hypertension Remission Outcomes Reported in Trials of Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME	FOLLOW-UP	REMISSION OUTCOME	RESULTS	*P* VALUE
Cohen, 2020[53] MOMS	2 years	Systolic BP < 130 mmHg	RYGB: 17 of 51 (33%) MT: 19 of 49 (38%)	$P = .61$
		Diastolic BP < 80 mmHg	RYGB: 14 of 51 (28%) MT: 10 of 49 (20%)	$P = .39$
Ikramuddin, 2013[55]	5 years	Systolic BP < 130 mmHg	RYGB: 44 of 60 (73%)	$P = .06$

AUTHOR, YEAR STUDY NAME	FOLLOW-UP	REMISSION OUTCOME	RESULTS	*P* VALUE
DSS			MT: 29 of 60 (49%)	
		Antihypertensive medication use	RYGB: 34 to 61 (47%) MT: 51 to 81 (67%)	*P* = .06

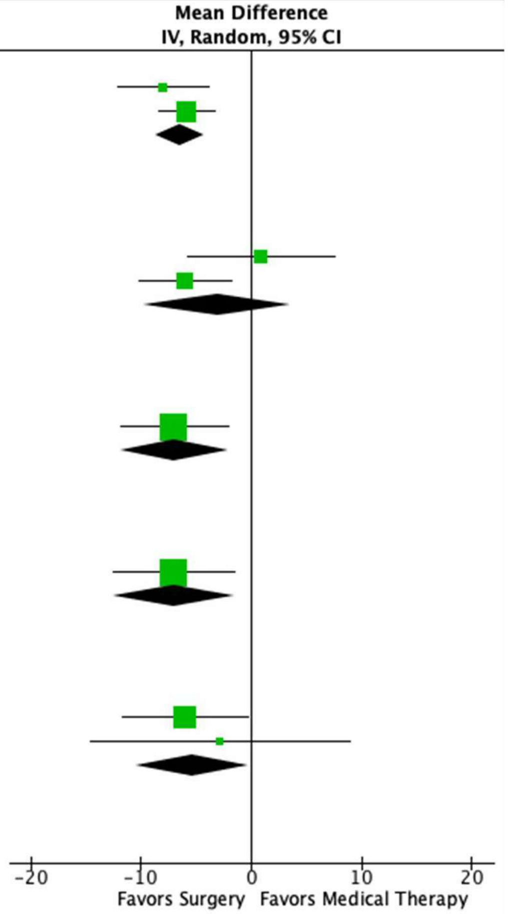
Abbreviations. BP: blood pressure; DSS: diabetes surgery study; mmHg: millimeters of mercury; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; RYGB: Roux-en-Y gastric bypass.

As shown in Table 14, comparative HTN remission outcomes were reported in 2 trials.[53,55] Neither trial observed a statistically significant difference in any measure of HTN remission at 2 to 5 years of follow-up.[53,55] In the Diabetes Surgery Study (DSS), which reported yearly follow-up rates up to year 5, there were also no significant differences in the proportion of participants achieving a systolic BP below 130 mmHg at years 1 through 4.[55] In contrast, significantly fewer surgical participants were using antihypertensive medications compared with medical therapy participants at DSS follow-up years 1 through 3, but no between-group differences were observed at years 4 or 5 (Appendix D, Table D7).[55] Additionally, subgroup analyses of antihypertensive medication use at 5 years, conducted by Parikh and colleagues, found no differences in the use of any or more than 1 BP-lowering medications by surgical procedure type (Appendix D, Table D7).[57]

Results regarding the effect of bariatric surgery on mean systolic or diastolic BP were mixed. Meta-analysis of mean values from 4 trials at yearly follow-up timepoints showed that systolic and diastolic BP were generally lower in bariatric surgery groups across 5 years of follow-up, but several timepoints only had data from a single trial and there were no significant between-group differences in either value reported in 2 of the 4 included trials (Figures 5 and 6).[53,55-57] In the DSS trial, the largest included US study, bariatric surgery participants had significantly lower mean systolic BP at all 5 years of follow-up compared with medical therapy participants (MD range, -8.0 to -6.0 mmHg) and significantly lower diastolic BP at years 1 through 4 (MD range, -6.0 to -4.0 mmHg), but not at year 5 (Appendix D, Table D7).[55] Conversely, in the TRIABETES study, which compared mean differences in BP values from baseline, the bariatric surgery group had significantly greater systolic BP reduction than the medical therapy group at year 5 (P = .008), but no significant between-group differences in at years 1 and 3; there were no between-group differences at any follow-up year for diastolic BP (Appendix D, Table D7).[54]

Figure 5. Mean Systolic Blood Pressure (mmHg) in Adults with BMI 30 to 34.9

Study or Subgroup	Surgery Mean	Surgery SD	Surgery Total	Medical Therapy Mean	Medical Therapy SD	Medical Therapy Total	Weight	Mean Difference IV, Random, 95% CI
3.1.1 1 year								
Ikramuddin 2013 (DSS)	115	11.3	57	123	11.3	57	27.2%	-8.00 [-12.15, -3.85]
Liang 2013	126.5	4.9	31	132.4	5.7	36	72.8%	-5.90 [-8.44, -3.36]
Subtotal (95% CI)			**88**			**93**	**100.0%**	**-6.47 [-8.64, -4.31]**
Heterogeneity: Tau² = 0.00; Chi² = 0.72, df = 1 (P = 0.40); I² = 0%								
Test for overall effect: Z = 5.86 (P < 0.00001)								
3.1.2 2 years								
Cohen 2020 (MOMS)	130.8	17.4	51	129.9	16.7	49	42.5%	0.90 [-5.78, 7.58]
Ikramuddin 2013 (DSS)	118	11.2	56	124	11	54	57.5%	-6.00 [-10.15, -1.85]
Subtotal (95% CI)			**107**			**103**	**100.0%**	**-3.07 [-9.75, 3.62]**
Heterogeneity: Tau² = 15.75; Chi² = 2.96, df = 1 (P = 0.09); I² = 66%								
Test for overall effect: Z = 0.90 (P = 0.37)								
3.1.3 3 years								
Ikramuddin 2013 (DSS)	122	11.1	55	129	13.5	46	100.0%	-7.00 [-11.88, -2.12]
Subtotal (95% CI)			**55**			**46**	**100.0%**	**-7.00 [-11.88, -2.12]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.81 (P = 0.005)								
3.1.4 4 years								
Ikramuddin 2013 (DSS)	122	14.8	55	129	13.5	46	100.0%	-7.00 [-12.52, -1.48]
Subtotal (95% CI)			**55**			**46**	**100.0%**	**-7.00 [-12.52, -1.48]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.48 (P = 0.01)								
3.1.5 5 years								
Ikramuddin 2013 (DSS)	124	11.1	55	130	16.2	43	81.2%	-6.00 [-11.66, -0.34]
Parikh 2014	132.8	20.2	29	135.6	17.5	14	18.8%	-2.80 [-14.55, 8.95]
Subtotal (95% CI)			**84**			**57**	**100.0%**	**-5.40 [-10.50, -0.30]**
Heterogeneity: Tau² = 0.00; Chi² = 0.23, df = 1 (P = 0.63); I² = 0%								
Test for overall effect: Z = 2.07 (P = 0.04)								



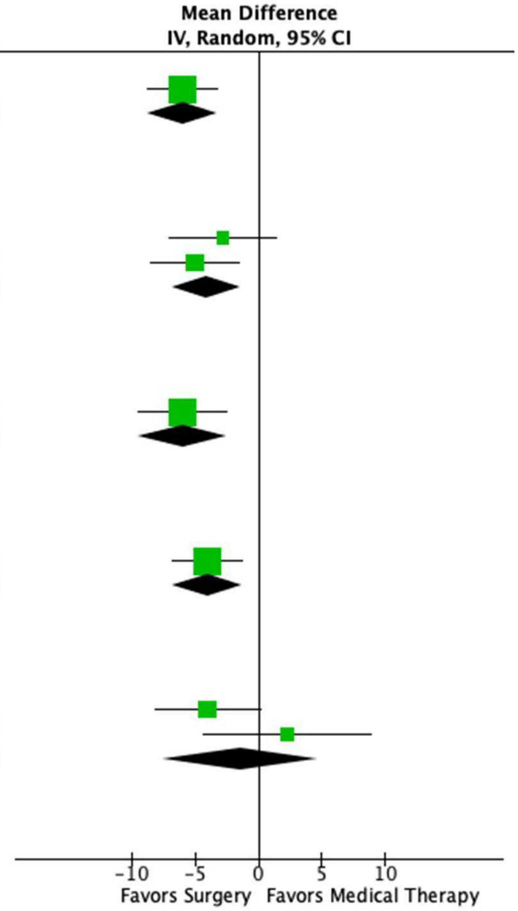
Test for subgroup differences: Chi² = 1.18, df = 4 (P = 0.88), I² = 0%

Note. Forest plot generated using Review Manager (RevMan) software, version 5.4

Abbreviations. BMI: body mass index; CI: confidence interval; DSS: diabetes surgery study; IV: inverse variance; mmHg: millimeters of mercury; MOMS: Microvascular Outcomes after Metabolic Surgery; M-H: Mantel-Haenszel test TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Figure 6. Mean Diastolic Blood Pressure (mmHg) in Adults with BMI 30 to 34.9

Study or Subgroup	Surgery Mean	Surgery SD	Surgery Total	Medical Therapy Mean	Medical Therapy SD	Medical Therapy Total	Weight	Mean Difference IV, Random, 95% CI
3.2.1 1 year								
Ikramuddin 2013 (DSS)	68	7.5	57	74	7.5	57	100.0%	-6.00 [-8.75, -3.25]
Subtotal (95% CI)			**57**			**57**	**100.0%**	**-6.00 [-8.75, -3.25]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 4.27 (P < 0.0001)								
3.2.2 2 years								
Cohen 2020 (MOMS)	79.7	11	51	82.5	10.4	49	41.3%	-2.80 [-6.99, 1.39]
Ikramuddin 2013 (DSS)	70	11.2	56	75	7.3	54	58.7%	-5.00 [-8.52, -1.48]
Subtotal (95% CI)			**107**			**103**	**100.0%**	**-4.09 [-6.79, -1.39]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.62$, df = 1 (P = 0.43); $I^2 = 0\%$								
Test for overall effect: Z = 2.97 (P = 0.003)								
3.2.3 3 years								
Ikramuddin 2013 (DSS)	71	7.4	55	77	10.1	46	100.0%	-6.00 [-9.51, -2.49]
Subtotal (95% CI)			**55**			**46**	**100.0%**	**-6.00 [-9.51, -2.49]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.35 (P = 0.0008)								
3.2.4 4 years								
Ikramuddin 2013 (DSS)	72	7.4	55	76	6.7	46	100.0%	-4.00 [-6.75, -1.25]
Subtotal (95% CI)			**55**			**46**	**100.0%**	**-4.00 [-6.75, -1.25]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.85 (P = 0.004)								
3.2.5 5 years								
Ikramuddin 2013 (DSS)	73	11.1	55	77	9.7	43	58.8%	-4.00 [-8.12, 0.12]
Parikh 2014	76.7	10.6	29	74.4	10.3	14	41.2%	2.30 [-4.33, 8.93]
Subtotal (95% CI)			**84**			**57**	**100.0%**	**-1.41 [-7.48, 4.67]**
Heterogeneity: $Tau^2 = 11.90$; $Chi^2 = 2.50$, df = 1 (P = 0.11); $I^2 = 60\%$								
Test for overall effect: Z = 0.45 (P = 0.65)								
Test for subgroup differences: $Chi^2 = 2.95$, df = 4 (P = 0.57), $I^2 = 0\%$								



Note. Forest plot generated using Review Manager (RevMan) software, version 5.4

Abbreviations. BMI: body mass index; CI: confidence interval; DSS: diabetes surgery study; IV: inverse variance; mmHg: millimeters of mercury; MOMS: Microvascular Outcomes after Metabolic Surgery; M-H: Mantel-Haenszel test TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

It is important to note that mean baseline systolic and diastolic BP values were generally within the range of stage 1 HTN (i.e., systolic BP 130 to 139 mmHg or diastolic BP 80 to 89 mmHg)[49] across trials and, with few exceptions, most study groups achieved mean B*P* values at or below the thresholds for HTN at follow-up, regardless of group assignment (Appendix D, Table D7).[53,55-57]

Coronary Artery Disease

Coronary artery disease-related outcomes were available for adults with BMI 30 to 34.9 in all included trials except for STAMPEDE. Rates of cardiac events were not reported in any trial, but intermediate outcomes such as use of heart disease-related medications and measures associated increased risk for cardiovascular disease (e.g., low-density lipoprotein cholesterol [LDL-C] and triglycerides levels) were available (Tables 15 and 16).

Table 15. Dichotomous Coronary Artery Disease-Related Outcomes Reported in Trials of Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME	FOLLOW-UP	OUTCOME	RESULTS	*P* VALUE
Cohen, 2020[53] MOMS	2 years	LDL-C < 100 mg/dL	RYGB: 34 of 46 (73%) MT: 24 of 46 (51%)	*P* = .05
		Triglycerides < 150 mg/dL	RYGB: 37 of 46 (80%) MT: 19 of 46 (42%)	*P* < .001
		Beta-blocker use	RYGB: 6 of 46 (13%) MT: 10 of 46 (22%)	*P* = .41
		Calcium channel blocker use	RYGB: 5 of 46 (11%) MT: 10 of 46 (22%)	*P* = .26
		ARB- or ACE-inhibitor use	RYGB: 41 of 46 (89%) MT: 40 of 46 (87%)	*P* = .99
Ikramuddin, 2013[55] DSS	5 years	LDL-C < 100 mg/dL	RYGB: 46 of 60 (77%) MT: 28 of 60 (47%)	*P* = .02

Abbreviations. ACE: angiotensin-converting enzyme; ARB: angiotensin receptor blocker; BMI: body mass index; DSS: diabetes surgery study; LDL-C: low-density lipoprotein cholesterol; mg/dL: milligrams per deciliter; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; RYGB: Roux-en-Y gastric bypass.

Table 16. Continuous Coronary Artery Disease-Relevant Outcomes in Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME YEAR	BASELINE	MAX FOLLOW-UP	DIFFERENCE (95% CI)	*P* VALUE
LDL-C, mg/dL				
Cohen, 2020[53] MOMS 2 years	RYGB: 102 (36.5) MT: 108.6 (41.1)	RYGB: 85.7 (76.3 to 95.0) MT: 101.6 (92.2 to 110.9)	MD, -15.9 (-29.1 to -2.65)	*P* = .02
Courcoulas, 2014[54] TRIABETES 5 years	RYGB: 117.8 (10.63) MT: 105.5 (7.45)	Mean values NR	RYGB: −9.43 (8.28) MT: −19.3 (8.25)	*P* = .39
Ikramuddin, 2013[55] DSS 5 years	RYGB: 102 (92 to 111) MT: 102 (91 to 113)	RYGB: 83 (75 to 91) MT: 98 (90 to 107)	MD, -15 (-27 to -4)	*P* = .01
Liang, 2013[56] 1 year	RYGB: 3.84 (0.63) MT: 3.72 (0.42)	RYGB: 1.97 (0.45) MT: 3.69 (0.48)	NR -1.72	*P* < .05
Parikh, 2014[57] 5 years	Surg: 106.6 (34.5) MT: 117.6 (60.4)	Surg: 111.0 (41.5) MT: 88.7 (29.6)	Surg: +4.4 (51.4) MT: -28.9 (50.8)	*P* = .054
Triglycerides, mg/dL				
Cohen, 2020[53] MOMS 2 years	RYGB: 195 (145 to 293) MT: 214 (150 to 334)	RYGB: 107.8 (90.6 to 140.3) MT: 180.7 (157.7 to 207.2)	MD, -67 (-102.1 to -31.9)	*P* < .001
Courcoulas, 2014[54] TRIABETES 5 years	RYGB: 169.7 (27.2) MT: 161.2 (24.5)	Mean values NR	RYGB: −78.0 (13.7) MT: −9.3 (14.6)	*P* < .001

AUTHOR, YEAR STUDY NAME YEAR	BASELINE	MAX FOLLOW-UP	DIFFERENCE (95% CI)	*P* VALUE
Ikramuddin, 2013[55] DSS 5 years	RYGB: 258 (154 to 362) MT: 250 (191 to 309)	RYGB: 116 (75 to 157) MT: 183 (137 to 228)	MD, −66 (−127 to −6)	*P* = .03
Liang[56] 1 year	RYGB: 3.39 (1.18) MT: 3.49 (1.32)	RYGB: 1.60 (0.13) MT: 3.50 (1.51)	NR	*P* < .05
Parikh, 2014[57] 5 years	Surg: 173.8 (92.6) MT: 139.5 (60.5)	Surg: 132.4 (58.4) MT: 153.6 (82.6)	Surg: -41.4 (90.3) MT: +14.1 (66.3)	*P* = .04

Abbreviations. CI: confidence interval; DSS: diabetes surgery study; LDL-C: low-density lipoprotein cholesterol; MD: mean difference; mg/dL: milligrams per deciliter; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; NR: not reported; RYGB: Roux-en-Y gastric bypass; Surg: bariatric surgery; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Findings regarding the effect of bariatric surgery on LDL-C were mixed. At final study follow-up, 3 studies observed significantly lower levels at of LDL-C in the bariatric surgery groups compared with medical therapy groups,[53,55,56] whereas 2 studies observed no between-group differences (Table 16).[54,57] In addition, results from 2 studies showed that that surgical participants were significantly more likely to be within the optimal LDL-C range (< 100 mg/dL) at 2- and 5-years follow-up (Table 15).[53,55]

In contrast with the mixed LDL-C findings, all surgical groups had significantly lower mean triglycerides levels over 1 to 5 years of follow-up compared with medical therapy groups (Table 16).[53-57] Moreover, results from the 2-year MOMS study showed that surgical participants were significantly more likely to be within the optimal triglycerides range (i.e., < 150 mg/dL) at follow-up (Table 15).[53]

Medication use was less widely reported. In the MOMS study, no between-group differences were observed the in use of medications to treat or prevent progression of heart disease (e.g., beta blockers) at 2 years (Table 15).[53]

Obstructive Sleep Apnea

We did not identify any eligible studies that assessed improvement or resolution of obstructive sleep apnea in adults with BMI 30.0 to 34.9.

Joint Arthropathy

We did not identify any eligible studies that assessed improvement or resolution of joint arthropathy in adults with BMI 30.0 to 34.9.

Intracranial Hypertension

We did not identify any eligible reviews of bariatric procedures that assessed improvement or resolution of intracranial HTN in adults with BMI 30.0 to 34.9.

Quality of Life

We identified 1 study that reported comparative QoL outcomes for adults with BMI 30 to 34.9 (Table 17). In the MOMS trial, QoL was assessed for all participants at 2 years post randomization and included several domains on the SF-36 scale, which is a validated non-condition-specific QoL survey (range: 0-100, with higher scores representing better health status). Domains for which the study groups differed at baseline (i.e., pain, social role functioning) were not assessed at the 2-year follow-up. No weight- or diabetes-specific measures of QoL were reported.

Table 17. Quality of Life Outcomes in Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME SAMPLE SIZE FOLLOW-UP	OUTCOME[a]	SF-36 SCORES[b]	DIFFERENCE (95% CI)	*P* VALUE
Cohen, 2020[53] MOMS N = 100 2 years	General health	RYGB: 78.15 (72.6 to 83.7) MT: 60.3 (54.8 to 65.8)	MD, 17.9 (10.0 to 25.7)	*P* < .001
	Emotional well-being	RYGB: 71.9 (66.2 to 77.8) MT: 63.0 (57.2 to 68.8)	MD, 8.9 (0.7 to 17.2)	*P* = .03
	Physical health	RYGB: 80.4 (68.8 to 92.1) MT: 60.5 (48.9 to 72.1)	MD, 19.9 (3.5 to 36.4)	*P* = .02
	Physical role functioning	RYGB: 84.3 (77.9 to 90.7) MT: 70.2 (63.8 to 76.6)	MD, 14.2 (5.1 to 23.2)	*P* = .002
	Mental health	RYGB: 73.5 (61.5 to 85.6) MT: 62.6 (50.6 to 74.7)	MD not reported	*P* = .21
	Vitality	RYGB: 69.5 (63.6 to 75.4) MT: 55.1 (49.2 to 61.0)	MD, 14.4 (6.1 to 22.7)	*P* = .001

Notes. [a] 24-month scores were only reported for measures where the study groups did not differ at baseline. SF-36 measures not reported due to imbalance at baseline include pain and social role functioning. [b] SF-36 domain scores range from 0 to 100, with higher scores indicating better functioning.

Abbreviations. BMI: body mass index; CI: confidence interval; MD: mean difference; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; RYGB: Roux-en-Y Gastric Bypass; SF-36: Short Form 36 Survey.

Except for mental health, individuals randomized to bariatric surgery reported better health status, as indicated by statistically significantly higher SF-36 scores, for all assessed domains as compared with participants randomized to medical therapy (Table 17).[53] To date, no minimal clinically important difference (MCID) has been established for the SF-36 in populations with obesity or diabetes, but the SF-36 user manual suggests that a difference of 2 to 3 points for any domain is clinically meaningful.[60] Using that threshold, those who received bariatric surgery also experienced clinically significant differential QoL improvement in most assessed domains.[53] The lack of differential mental health related QoL scores between MOMS study groups, despite evidence of significant differential weight loss and T2DM with bariatric surgery, suggests that emotional and social mental health challenges may persist regardless of physical health improvements.[53]

Harms

Harms data varied in both reported outcomes and recorded event types across the included trials of adults with BMI 30 to 34.9. Commonly reported outcomes across studies included surgically related adverse events and serious adverse events (Table 18).

Table 18. Adverse and Serious Adverse Events in Trials of Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME	FOLLOW-UP	ADVERSE EVENTS	SERIOUS ADVERSE EVENTS
Cohen, 2020[53] MOMS	2 years	RYGB: 6 events in 46 participants MT: 6 events in 46 participants	NR
Courcoulas, 2014[54] TRIABETES	5 years	RYGB: 21 events in 20 participants MT: 14 events in 20 participants	Post-operative (< 30 days) RYGB: 0 events Late-operative (> 30 days) RYGB: 1 event (anastomotic ulcer) Non-operative (> 30 days) RYGB: 0 events MT 0 events
Ikramuddin, 2013[55] DSS	5 years	RYGB: 66 events in 60 participants MT: 38 events in 60 participants	RYGB: 26 events in 60 participants MT: 19 events in 60 participants
Liang, 2013[56]	1 year	NR	No events occurred
Parikh, 2014[57]	5 years	NR	Hospital readmissions or reoperations 11 events in 29 participants

Abbreviations. BMI: body mass index; DSS: diabetes surgery study; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; NR: not reported; RYGB: Roux-en-Y gastric bypass; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Adverse events (i.e., events requiring minimal intervention) were generally more common in bariatric surgery groups compared with medical therapy groups due primarily to early surgical complications (Table 18).[53-57] Common adverse events that occurred outside of the perioperative period (i.e., > 30 days post-surgery) included nausea, dehydration, diarrhea, mild hypoglycemia, and upper gastrointestinal pain.

Few serious adverse events (i.e., events requiring intensive medical intervention) occurred in any study group (Table 18).[53-57] Reported events were generally related to additional surgeries (e.g., gallbladder or appendix removal, or hospitalizations for infection (e.g., sepsis, abscesses). Rates of serious adverse events were higher overall in the DSS trial, which may be due to the wide range of events that were considered for inclusion in event counts (e.g., unplanned pregnancy, bone fractures).[55] Rates of bariatric surgery revisions were not systematically reported in any of the included studies.

Nutritional abnormalities were only reported in the DSS trial (Appendix D, Table D6).[55] There were no between-group differences in instances of vitamin B12 deficiency, vitamin D deficiency, or anemia over the 2-year nutritional analysis.[55] However, rates of iron deficiency were significantly higher in the bariatric surgery group compared with the medical therapy group at 2 years (20% vs. 0%; $P < .01$).[55]

Ongoing Studies

One recent publication described ongoing RCTs for bariatric procedures worldwide including studies representing populations on 6 continents based on a map of registered trials.[52] The authors identified 16 ongoing RCTs evaluating participants with baseline BMIs between 25 and 35 kg/m^2.[52] Studies are open to individuals with and without T2DM. Most of the studies plan to investigate the effectiveness of RYGB and SG and will largely focus on the ability of bariatric surgery to treat chronic conditions related to obesity (e.g., T2DM, HTN), improve QoL, and increase weight loss.[52] Notably, at least 1 clinical trial in this population intends to evaluate the SADI-S procedure.[52] None of the identified RCTs enrolled participants younger than 18 years of age.[52]

Adolescents

We identified 3 prospective observational studies[24,61,62] and 1 comparative post-hoc analysis[63] of 2 prospective studies of bariatric surgery in adolescents (Table 19). The Teen–Longitudinal Assessment of Bariatric Surgery (Teen-LABS)[61] and Follow-up of Adolescent Bariatric Surgery at 5 Plus years (FABS-5+)[24] were uncontrolled pre-post evaluations of adolescents undergoing bariatric surgery. Adolescent Morbid Obesity Surgery (AMOS)[62] and Teen-LABS/Treatment Options of Type 2 Diabetes in Adolescents and Youth (TODAY)[63] compared adolescents undergoing surgery with those who received behavioral or pharmacologic interventions (i.e., medical therapy). Study sample sizes ranged from 58 to 242 participants with study follow-up durations of 2 to 12.5 years. Most surgical participants received gastric bypass procedures (79%), followed by sleeve gastrectomy (18%) and gastric banding (3%). Although mean age was similar across all study groups (range, 15.3 to 17.1 years), surgical groups had older age ranges than control groups (13 to 21 years vs. 10 to 18 years, respectively). See Appendix D, Table D8 for details regarding study inclusion criteria and additional participant characteristics.

During the literature review we identified one clinical trial that randomized adolescents to bariatric surgery or medical therapy.[64] However, this trial was ultimately excluded because it was published prior to 2012 and all surgical participants received gastric banding.

Table 19. Characteristics of Included Studies of Adolescents

AUTHOR, YEAR STUDY NAME RISK OF BIAS	STUDY POPULATION	TOTAL SAMPLE MAX FOLLOW-UP COUNTRY	STUDY GROUP	N, GROUP	MEAN AGE (YEARS)	MEAN BMI (kg/m^2)
Inge, 2014[61,65-69] Teen-LABS Moderate	Severely obese adolescents undergoing weight loss surgery	N = 242 5 years United States	Surgery (RYGB, SG, or AGB)	N = 242 RYGB: 161 SG: 67 AGB: 14	17.1 (1.6) Range: 13 to 19	50.5 (45.2 to 58.3) Range: 34.0 to 87.7
Inge, 2017[24] FABS-5+ High	Adolescents who received RYGB for clinically severe obesity	N = 58 Mean: 8.0 years Range: 5.4–12.5 years United States	RYGB	N = 58	17.1 (1.7) Range: 13 to 21	58.5 (10.5)
Inge, 2018[63,70] Teen-LABS/TODAY High	Severely obese adolescents with T2DM	N = 93 2 years United States	Surgery (RYGB or SG from Teen-LABS)	N = 30	16.9 (1.3) Range: 13 to 19	54.4 (9.5)
			MT (any TODAY study group)[a]	N = 63	15.3 (1.3) Range: 10 to 17	40.5 (4.9)
Olbers, 2012[62,71] AMOS Moderate	Adolescents (13–18 years) with a BMI range 36–69 kg/m^2	N = 162[b] (adolescent groups only) 5 years Sweden	RYGB	N = 81	16.5 (1.2)	45.5 (6.0)
			MT	N = 81	15.8 (1.2)	42.2 (5.0)

Notes. [a] The TODAY trial compared several forms of medical therapy for adolescent T2DM including lifestyle management alone or in combination with metformin and other weight loss medications. [b] The AMOS study also included an adult RYGB comparison group (N = 80), the results of which are not reported in this coverage guidance. Including the adult group, total AMOS enrollment was 242 individuals.
Abbreviations. AGB: adjustable gastric banding; AMOS: Adolescent Morbid Obesity Surgery; BMI: body mass index; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; MT: medical therapy; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; T2DM: type 2 diabetes mellitus; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

All-cause Mortality

We did not identify any eligible studies that estimated all-cause mortality in adolescents.

Weight Change

All 4 included adolescent studies reported weight change outcomes (Table 20; Appendix D, Table D9).[24,61-63] Weight change was described by changes in absolute weight in kilograms and changes in BMI.

Table 20. Weight Change Outcomes from Included Adolescent Studies

STUDY NAME	SAMPLE SIZE STUDY DURATION	BASELINE	FOLLOW-UP	MEAN DIFFERENCE (95% CI)	% CHANGE
Weight, kg					
Teen-LABS[61]	N = 242 3 years	149.0	108.0	-41 (-45 to -37) *P* < .001	-27% (-29 to -25) *P* < .001
AMOS[62]	N = 162 5 years	Surg: 133.0 MT: 124.0	Surg: 96.0 MT: 133.3	Within-group Surg: -36.8 (-40.9 to -32.8) MT: +9.3 (NR) Between group -37.2 (-46.4 to -28.0); *P* < .001	NR
FABS-5+[24]	N = 58 5 to 12 years	170.8	120.9	-50.0 (-56.8 to -43.1)	-29.5% (-33.2 to -25.7)
Teen-LABS/ TODAY[63]	N = 93 2 years	Surg: 155.1 MT: 117.4	Surg: 110.9 MT: 123.2	Surg: -44.2 (-50.6 to -37.8) MT: +5.8 (1.4 to 10.2) *P* < .001	NR
BMI, kg/m²					
Teen-LABS[61]	N = 242 3 years	53	38	-15 (-16 to -13)	-28% (-30 to -25)
AMOS[62]	N = 162 5 years	Surg: 45.5 MT: 42.2	Surg: 32.3 MT: 44.6	Within-group Surg: -13.1 (-14.5 to -11.8) MT: +3.3 (1.1 to 4.8) Between-group -12.26 (-15.2 to -9.3); *P* < .001	NR
FABS-5+[24]	N = 58 5 to 12 years	58.5	41.5	-17.0 (-19.2 to -14.8)	-29.3% (-33.0 to -25.6)
Teen-LABS/ TODAY[63]	N = 93 2 years	Surg: 51.8 MT: 36.7	Surg: 36.3 MT: 37.9	Surg: -15.1 (-17.3 to -13.0) MT: +1.3 (-0.2 to 2.8) *P* < .001	NR

Abbreviations. AMOS: Adolescent Morbid Obesity Surgery, BMI: body mass index; CI: confidence interval; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; kg: kilograms; MT: medical therapy; NR: not reported; Surg: bariatric surgery, any type; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

Results from these studies showed that adolescents who underwent bariatric procedures experienced statistically significant weight reductions ranging from -36.8 to -50.0 kg and BMI reductions ranging from -13.0 to -17.0 kg/m^2 over 2 to 12 years follow-up.[24,61-63] These findings corresponded to a nearly 30 percent reduction in weight and BMI across studies in surgical study groups (Table 20).[24,61-63] Additionally, in the 3-year Teen-LABS study of adolescents who underwent bariatric surgery (N = 242), 70 percent of participants had BMI reductions of 20 percent or more and only 2 percent of participants exceeded their baseline BMI.[61,66] Despite these observed weight reductions across adolescent studies, it should be noted that a substantial proportion of study participants continued to have obesity following surgical interventions, as indicated by mean postsurgical BMI (range, 32.3 to 41.5).

Subgroup analyses of the Teen-LABS cohort (Appendix D, Table D9) did not find any significant differences in weight change outcomes by age group (i.e., 13–15 years vs. 16–19 years).[61,66] Results stratified by surgical type, however, showed that participants who received AGB did not demonstrate significant percent weight change at the 3-year follow-up (-8.1% [95% CI, -19.9 to 3.6]) compared to participants who underwent RYGB (-28% [95% CI, -30 to -25]) or SG (-26% [95% CI, -30 to -22]).[61,66] Owing to these results, AGB was subsequently excluded from a limited 5-year assessment of BMI in which participants were found to have sustained lower mean BMIs compared with baseline whether they received RYGB (54 vs. 39) or SG (50 vs. 37).[65]

In the Teen-LABS/TODAY and AMOS matched cohort studies, surgical study groups experienced statistically significant (i.e., $P < .001$) mean weight and BMI reductions compared with medical therapy groups.[62,63,71] In the 2-year Teen-LABS/TODAY study, surgical participants experienced significant weight reduction during follow-up whereas medical therapy controls experienced significant weight gain (-44.2 kg [-50.6 to -37.8] vs. +5.8 [1.4 to 10.2]; $P < .001$).[63] These weight changes corresponded with a significant mean BMI reduction in the surgical group compared with no significant change in the control group (-15.1 kg/m^2 [95% CI, -17.3 to -13.0] vs. +1.3 kg/m^2 [95% CI, -0.2 to 2.8]; $P < .001$).[63] In the 5-year AMOS study, surgical participants experienced statistically significant mean weight loss (MD, -37.2 [95% CI, -46.4 to -28.0]; $P < .001$) and mean BMI reduction (MD, -12.26 [95% CI, -15.2 to -9.3]; $P < .001$) compared with the medical therapy group (Table 20).[62,71] Moreover, 70 percent of the surgical group lost 20 percent or more of their total body weight, whereas 69 percent of the medical therapy group gained weight and a greater proportion of surgical participants achieved a BMI less than 30 (37% vs. 3%; Appendix D, Table D9).[62,71] Taken together, these comparative results suggest that bariatric procedures are associated with substantial and sustained weight loss compared with medical therapy interventions in adolescents.

Change in Chronic Disease Status

Table 21 details rates of chronic disease remission or resolution reported in the included adolescent studies.[24,61-63] As with adult populations, definitions for remission or resolution varied between studies, particularly for T2DM.

Table 21. Chronic Disease Resolution in Adolescents

STUDY NAME SAMPLE SIZE	FOLLOW-UP	DIABETES	HYPERTENSION[a]	ELEVATED CVD RISK
Teen-LABS/ TODAY[63] N = 93	2 years	T2DM remission Surg: 85.7% (12 of 14) MT: 0% (0 of 24)	Elevated BP remission Surg: 75% (15 of 20) MT: 0% (0 of 13)	NR
Teen-LABS[61] N = 242	3 years	T2DM remission 95% (19 of 20 participants) Adjusted: 90% (65 to 98) Prediabetes remission 76% (13 of 17) Adjusted: 77% (48 to 92)	Elevated BP remission 74% (56 of 76) Adjusted: 73% (60 to 83)	NR
AMOS[62] N = 162	5 years	T2DM remission Surg: 100% (3 of 3) MT: NR Elevated HbA1c resolution (≥ 39 mmol/mol) Surg: 62.5% (5 of 8) MT: NR Impaired FPG[d] resolution Surg: 100% (13 of 13) MT: NR	Elevated BP remission (SBP ≥140 mmHg or DBP ≥ 90 mmHg) Surg: 100% (12 of 12) MT: NR Elevated SBP (≥ 140 mmHg) remission Surg: 100% (11 of 11) MT: NR Elevated DBP (≥ 90 mmHg) remission Surg: 100% (4 of 4) MT: NR	Elevated LDL-C[b] resolution Surg: 100% (13 of 13) MT: NR Elevated triglycerides[c] resolution Surg: 100% (22 of 22) MT: NR
FABS-5+[24] N = 58	5-12 years	T2DM remission 87.5% (7 of 8)	Elevated BP remission 76% (19 of 25)	NR

Notes. [a] Elevated BP is defined as use of BP-lowering medications or SBP ≥ 95th percentile or DBP ≥ 95th percentile (for age, sex, height) if < 18 years of age; or if ≥ 18 years, SBP > 140 mmHg or DBP > 90 mmHg. Remission of elevated BP required absence of BP-lowering medications, and SBP and DBP in the normal range for age. [b] Elevated LDL-C defined as ≥ 3.37 mmol/L or ≥ 130 mg/dL. [c] Elevated triglycerides defined as ≥ 1.47 mmol/L or ≥ 130 mg/dL. [d] Impaired FPG defined as ≥ 5.6 mmol/L.

Abbreviations. AMOS: Adolescent Morbid Obesity Surgery; BP: blood pressure; CVD: cardiovascular disease; DBP: diastolic blood pressure; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; FPG: fasting plasma glucose; HbA1c: glycated hemoglobin; LDL-C: low-density lipoprotein cholesterol; MT: medical therapy; NR: not reported; SBP: systolic blood pressure; Surg: bariatric surgery, any type; T2DM: type 2 diabetes mellitus; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

Table 22 reports changes in important mean continuous variables reported in the included adolescent studies. Reported measures were intermediate or associated indicators for T2DM (HbA1c and fasting plasma glucose), HTN (systolic and diastolic BP), and risk for heart disease (LDL-C and triglycerides levels).

Table 22. Chronic Condition-Relevant Continuous Outcomes in Adolescents

STUDY NAME	BASELINE	FOLLOW-UP	DIFFERENCE (95% CI)	*P* VALUE
HbA1c, %				
Teen-LABS/ TODAY[63] N = 93	Surg: 6.8% MT: 6.4%	Surg: 5.5% MT: 7.8%	Surg: -1.3 (-2.2 to -0.5) MT: +1.4 (0.9 to 1.9)	*P* < .001
Teen-LABS[61] N = 242	--	--	--	--
AMOS[62] N = 162	Surg: 5% MT: NR	Surg: 5.2% MT: 5.4%	Surg vs. MT -19.7 mg/dL (-29.2 to +19.7)	*P* = .32
FABS-5+[24] N = 58	5.3%	5.2%	NR	NR
FPG, mg/dL				
Teen-LABS/ TODAY[63] N = 93	Surg: 125.1 MT: 119.2	Surg: 89.3 MT: 151.8	Surg: -35.8 (-53.9 to -17.7) MT: +32.6 (21.1 to 44.2)	*P* < .001
Teen-LABS[61] N = 242	--	--	--	--
AMOS[62] N = 162	Surg: 91.8 MT: NR	Surg: 86.4 MT: 93.6	Surg vs. MT -8.1 (-14.4 to -1.8)	*P* = .009
FABS-5+[24] N = 58	96.7	85.5	NR	NR
SBP, mmHg				
Teen-LABS/ TODAY[63] N = 93	Surg: 122.9 MT: 119.3	Surg: 122.0 MT: 120.8	Surg: −0.8 (−6.3 to 4.7) MT: +1.5 (−1.4 to 4.5)	NR
Teen-LABS[61] N = 242	--	--	--	--
AMOS[62] N = 162	Surg: 124.6 MT: NR	Surg: 113.2 MT: 121.4	Surg vs. MT −8.18 (−12.5 to −3.8)	*P* < .001
FABS-5+[24] N = 58	--	--	--	--
DBP, mmHg				
Teen-LABS/ TODAY[63] N = 93	Surg: 75.4 MT: 71.3	Surg: 73.3 MT: 71.4	Surg: −2.1 (−6.2 to 2.0) MT: +0.1 (−2.6 to 2.8)	NR
Teen-LABS[61] N = 242	--	--	--	--
AMOS[62] N = 162	Surg: 76.9 MT: NR	Surg: 69.4 MT: 77.7	Surg vs. MT −8.28 (−12.2 to −4.4)	*P* < .001
FABS-5+[24] N = 58	--	--	--	--
LDL-C, mg/dL				
Teen-LABS/ TODAY[63] N = 93	Surg: 92.0 MT: 89.0	Surg: 85.2 MT: 82.8	Surg: −6.8 (−22.2 to 3.9) MT: −6.2 (−15.4 to 2.9)	NR

STUDY NAME	BASELINE	FOLLOW-UP	DIFFERENCE (95% CI)	*P* VALUE
Teen-LABS[61] N = 242	--	--	--	--
AMOS[62] N = 162	Surg: 100.5 MT: NR	Surg: 85.1 MT: 116.0	Surg vs. MT -34.0 (-46.4 to -23.2)	*P* < .001
FABS-5+[24] N = 58	107.5	94.4	NR	NR
Triglycerides, mg/dL				
Teen-LABS/ TODAY[63] N = 93	Surg: 108.8 MT: 100.7	Surg: 88.1 MT: 116.1	Surg: −20.7 (−24.4 to −17.4) MT: +15.4 (10.4 to 21.8)	NR
Teen-LABS[61] N = 242	--	--	--	--
AMOS[62] N = 162	Surg: 115.0 MT: NR	Surg: 79.7 MT: 123.9	Surg vs. MT -41.6 (-62.0 to 17.7)	*P* < .001
FABS-5+[24] N = 58	128.3	87.6	NR	NR

Abbreviations. AMOS: Adolescent Morbid Obesity Surgery; CI: confidence interval; DBP: diastolic blood pressure; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; FPG: fasting plasma glucose; HbA1c: glycated hemoglobin; LDL-C: low-density lipoprotein cholesterol; mg/dL: milligrams per deciliter; mmHg: millimeters of mercury; MT: medical therapy; NR: not reported; SBP: systolic blood pressure; Surg: bariatric surgery, any type; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

Diabetes

Across all included adolescent studies, substantial proportions of adolescents with T2DM who underwent bariatric procedures (N = 45) experienced remission (86% to 100%).[24,61-63] In comparison, no remission occurred among the medical therapy participants with T2DM (N = 24) in the 2-year Teen-LABS/TODAY analysis, the only study that reported nonsurgical remission rates (Table 21).[63] Additional subgroup analyses of the Teen-LABS bariatric surgery cohort (Appendix D, Table D10) did not find any significant differences in rates of T2DM remission by surgical type (i.e., RYGB, SG) at the 3-year follow-up; however, participants aged 13 to 15 years at enrollment were significantly less likely to achieve T2DM remission compared with participants aged 16 to 19 years (RR, 0.86 [95% CI, 0.74 to 0.99]; *P* = .046).[66]

In the Teen-LABS/TODAY and AMOS matched cohort studies,[62,63,71] surgical study groups experienced statistically significant differential reductions in mean FPG levels compared with medical therapy groups, but the treatment effect on HbA1c concentrations was mixed (Table 22). In the 2-year Teen-LABS/TODAY study, surgical participants experienced statistically significant mean HbA1c and FPG reductions during follow-up, whereas medical therapy controls had a significant increase in both measures (HbA1c: -1.3% vs. +1.4%, *P* < .001; FPG: -35.8 vs. +32.6 mg/dL, *P* < .001) (Table 22).[63] In contrast, although almost 63% of surgical participants with elevated baseline HbA1c values (i.e., ≥ 39 mmol/mol [5.7%]) in the AMOS study were in the normal range at the 5-year follow-up, mean follow-up values were not significantly different from the medical therapy group (33.5 vs. 35.3 mmol/mol; MD, -1.8 mmol/mol [95% CI, -5.4 to 1.8]; *P* = .32).[71] Mean FPG values among surgical participants, however, were statistically lower compared with nonsurgical participants at follow-up (-8.1 mg/dL [95% CI, -14.4 to -

1.8]; *P* = .009) and 100% of participants in the surgical group with impaired FPG (≥ 5.6 mmol/L) at baseline experienced remission at 5 years (Table 22; Appendix D, Table D10).[71]

Hypertension

Across all included adolescent studies, 74 to 100 percent of adolescents with elevated BP (i.e., systolic BP ≥ 120-129 mmHg and diastolic BP < 80 mmHg) or HTN (i.e., BP ≥ 130/80)[72] who underwent bariatric procedures experienced remission over the 2 to 12 years of available study follow-up (Table 21).[24,61-63] Comparatively, no remission occurred among the medical therapy participants with elevated BP (N = 13) in the 2-year Teen-LABS/TODAY analysis, the only study that reported nonsurgical remission rates (Table 21).[63] In addition, no significant differences in remission rates by age or surgical type were observed in subgroup analyses of surgical participants in the Teen-LABS study (Appendix D, Table D10).

Despite the high rates of elevated BP and HTN remission observed among a relatively small cohort of adolescent bariatric surgery recipients, comparative results for mean systolic and diastolic BP values in the Teen-LABS/TODAY and AMOS matched cohort studies were mixed (Table 22). At the 2-year follow-up in the Teen-LABS/TODAY study, there were no clinical (i.e., 20 mmHg for systolic BP, 10 mmHg for diastolic BP) or statistically significant differences from baseline in either study group with respect to mean systolic or diastolic BP values.[63] Compared with medical therapy, bariatric surgery in the AMOS study was associated with significant differential reductions in both systolic BP (-8.18 mmHg [95% CI, -12.5 to -3.8]; *P* < .001) and diastolic BP (-8.28 mmHg [95% CI, -12.2 to -4.4]; *P* < .001) at the 5-year follow-up.[71] However, reported within-group changes from baseline in systolic and diastolic BP in the surgical group (-11.5 and -7.4 mmHg, respectively) did not meet the generally accepted thresholds for clinically significant change; medical therapy within-group changes were not reported.[71]

Coronary Artery Disease

Coronary artery disease in adolescents is rare and, when present, is generally the result of genetic or congenital abnormalities.[73] To that end, we included results of intermediate measures known to be associated with increased risk of heart disease risk, such as elevated LDL-C[74] and triglycerides levels,[75] that were reported within the included adolescent studies.

In the AMOS study, all instances of elevated LDL-C (N = 13) or elevated triglycerides (N = 22) present among bariatric surgery participants at baseline resolved to normal levels at the 5-year follow-up, but no comparator group results were reported (Table 21).[62,71]

Both included comparative studies of adolescents (Teen-LABS/TODAY and AMOS) observed significant differential reductions in mean triglycerides at follow-up among teens who received surgical compared with medical therapy, but results were mixed for LDL-C levels (Table 22).[63,71] In Teen-LABS/TODAY study, participants who received bariatric surgery had a statistically significant reduction in triglycerides at the 2-year follow-up (-20.7 mg/dL [-24.4 to -17.4]) whereas medical therapy participants experienced a significant increase (+15.4 mg/dL [95% CI, 10.4 to 21.8]); however, neither study group experienced a significant change in LDL-C levels.[63] In the AMOS study, surgical participants had statistically significant differential reductions in both triglycerides (MD, -41.6 mg/dL [95% CI, -62.0 to 17.7]; *P* < .001) and LDL-C levels (MD, -34.0 mg/dL [95% CI, -46.4 to -23.2]; *P* < .001) compared with nonsurgical participants.[71]

In addition to observed data, Teen-LABS/TODAY investigators conducted a modeling analysis to estimate between-group 30-year heart disease event risk.[70] The model was based on age-adjusted cardiovascular disease (CVD) event models from the Framingham Heart Study and included assessment of multiple risk variables (e.g., BMI, BP, T2DM status, lipid profiles, smoking status).[70] Results of the modeling study suggested that the likelihood of 30-year CVD events (e.g., MI, stroke, congestive heart failure) may be substantially lower among adolescents with obesity and T2DM who received bariatric surgery compared with those who received medical therapy only (modeled 30-year risk of any cardiovascular event after 5 years of study follow-up: 6.8% vs 13.6%, respectively).[70]

Obstructive Sleep Apnea

We did not identify any eligible studies that assessed improvement or resolution of OSA in adolescents.

Joint Arthropathy

We identified 1 study (Teen-LABS) that reported on joint-related morbidities among adolescents.[61,68] Prior to surgery, 25 percent of participants reported substantial musculoskeletal pain concerns (i.e., knee, hip, calf, back) during or after a 400-meter walk test.[68] During follow-up assessments, rates of musculoskeletal pain concerns associated with postsurgical walk tests were significantly reduced at both 12 months (8%; RR, 0.62 [95% CI, 0.51 to 0.71]; $P < .01$) and 24 months (12%; RR, 0.47 [95% CI, 0.37 to 0.62]; $P < .01$) after adjusting for age, sex, race or ethnicity, baseline BMI, and surgical center.[68]

Intracranial Hypertension

We did not identify any eligible studies that assessed intracranial HTN.

Quality of Life

Two studies (Teen-LABS and AMOS) reported longitudinal QoL outcomes in their adolescent participants, including weight-related and general QoL measures (Table 23).[61,62]

Table 23. Quality of Life Outcomes in Adolescents

STUDY SAMPLE SIZE FOLLOW-UP	OUTCOME	BASELINE	FOLLOW-UP	DIFFERENCE (95% CI)	*P* VALUE
Teen-LABS[61,66] N = 242 3 years	Weight-related QOL (IWQoL-Kids score)[a]	63 (61 to 65)	83 (81 to 86)	Absolute change: +20.0 (17.4 to 22.7) Percent change: +42.6% (32.6 to 52.5)	$P < .001$ $P < .001$
AMOS[62,71] N = 162 5 years	Weight-related QOL (OP-14 Scale)[b]	Surg: 49.1 MT: NR	Surg: 37.4 MT: 45.1	Surg only -13.0 (-19.6 to -6.4) Surg vs. MT -7.9 (-20.7 to 4.5)	$P < .001$ $P = .22$
	Physical function (SF-36)[c]	Surg: 72.1 MT: NR	Surg: 84.4 MT: 75.9	Surg only 13.5 (8.1 to 19.0) Surg vs. MT 8.8 (0.0 to 17.6)	$P < .001$ $P = .05$
	Physical role function (SF-36)[c]	Surg: 75.9 MT: NR	Surg: 83.9 MT: 71.3	Surg only 11.2 (4.0 to 18.3) Surg vs. MT 13.5 (2.2 to 24.8)	$P = .002$ $P = .02$

STUDY SAMPLE SIZE FOLLOW-UP	OUTCOME	BASELINE	FOLLOW-UP	DIFFERENCE (95% CI)	*P* VALUE
	General health perceptions (SF-36)[c]	Surg: 53.8 MT: NR	Surg: 64.8 MT: 56.2	Surg only 12.4 (6.5 to 18.3) Surg vs. MT 8.7 (-1.1 to 18.5)	*P* < .001 *P* = .08
	Physical component (SF-36)[c]	Surg: 44.1 MT: NR	Surg: 48.3 MT: 45.7	Surg only 5.2 (2.5 to 7.9) Surg vs. MT -2.9 (-6.9 to 1.0)	*P* < .001 *P* = .14
	Other domains (SF-36)[c]	No significant within- or between-group differences at follow-up in the following SF-36 domains: bodily pain, vitality, mental health, social role function, emotional role function, mental component score			

Notes. [a] IWQoL-Kids score range is 0 to 100 with higher scores indicating better weight-related quality of life. [b] OP-14 score range is 0 to 100 with lower scores indicating decreased weight-related problems. [c] SF-36 has a score range of 0 to 100 with higher scores indicating better QOL. Abbreviations. AMOS: Adolescent Morbid Obesity Surgery; CI: confidence interval; IWQoL-Kids: Impact of Weight on Quality of Life-Kids; MT: medical therapy; NR: not reported; OP-14: Obesity-related Problems Scale; QOL: quality of life; SF-36: Short Form-36 Health Survey; Surg: bariatric surgery, any type; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery.

The Teen-LABS and AMOS studies both assessed measures of weight-related QoL (Table 23). At the 3-year follow-up assessment, Teen-LABS study participants–who all received bariatric surgery–reported a statistically significant improvement in the effect of weight on their overall well-being including physical limitations, self-esteem, and interpersonal relationships as measured by the Impact of Weight on Quality of Life-Kids scale (+20-points [95% CI, 17.4 to 22.7]; *P* < .001). These score differences also exceeded the clinically significant threshold of 4.8 points.[66,76] Similarly, surgical participants in the AMOS comparative cohort study reported a significant reduction in weight-related distress during activities such as shopping, swimming, eating at restaurants, and intimate relations at the 5-year assessment, as measured by the Obesity-related Problems Scale (-13.0 points [95% CI, -19.6 to -6.4]; *P* < .001; clinically important threshold not available).[71] However, surgical group scores did not differ significantly from control group scores (37.4 vs. 45.1 points; *P* = .22).[71]

The AMOS study also reported on several measures of general QoL as measured by the SF-36 survey (Table 23). Compared with the nonsurgical group, surgical participants only experienced differential improvements in 2 of the 10 assessed domains (i.e., physical function [+8.8 points; *P* = .05] and physical role limitations [+13.5 points; *P* = .02]).[71] Notably, surgical participants did not experience significant within- or between-group differences in any mental health or emotional functioning domain despite experiencing statistically significant weight loss compared with nonsurgical controls, indicating that mental health QoL issues for adolescents may persist in the long-term even when weight loss occurs.[71] As mental health disorders are common among adolescents regardless of weight status, conclusions regarding mental health outcomes in adolescents undergoing bariatric surgery should consider the multifactorial nature of these conditions.[77]

Harms

Table 24 details adverse events (AE) reported in the included adolescent studies. Event categories include perioperative events (occurring ≤ 30 days postsurgery), long-term AE (e.g., additional surgeries, deaths), and nutritional abnormalities.

Table 24. Harms Outcomes from Included Adolescent Studies

OUTCOME	TEEN-LABS/ TODAY N = 93 2 YEARS	TEEN-LABS N = 242 3 YEARS	AMOS N = 162 5 YEARS	FABS-5+ N = 58 5 TO 12 YEARS
Perioperative events (≤ 30 days)				
Major events (i.e., life-thereatening or additional surgeries)	NR	8% (19 of 242 patients; 20 events)	Surg: 17% (14 of 81 patients; 14 events) -12 sugeries (hernia repair and gall bladder removal) -2 suicide attempts in participants with preexisting depression MT: NR	NR
Minor events	NR	15% (36 of 242 patients; 47 events)	Surg: 5% (8 of 162 partients; 8 events) -4 ED visits for abdominal pain -1 instance of suicidal ideation -3 referrals to psychiatric unit MT: NR	NR
Long-term adverse events (> 30 days)				
Deaths	No deaths	3 deaths	No reported deaths	2 deaths
Additional abdominal surgeries (any)	Surg: 40% (12 of 30) MT: 0	13% (30 of 228 patients; 47 events)	Surg: 25% (20 of 81) MT: NR	12% (7 of 58)
Cholecystecomies		NR, but most of the 47 additional abdominal surgeries were gall bladder removals	Surg: 11% (9 of 81) MT: NR	21% (12 of 58)
Endoscopic procedures	NR	13% (29 of 228 patients; 48 events)	NR	22% (13 of 58)
Anemia-related blood transfusions	Surg: 0 MT: 2% (1 of 63)	NR	Surg: 2% (2 of 81) MT: NR	3% (2 of 58)
Inpatient psychiatric evaluation	NR	NR	Surg: 7% (6 of 81) MT: NR	NR
Nutritional abnormalities				
Low vitamin A	NR	13% (22 of 170)	NR	NR
Low vitamin B12	NR	8% (13 of 160)	Surg: 66% (16 of 73) MT: 6% (2 of 31) *P*= .05	16% (8 of 50)
Low vitamin D	NR	43% (74 of 172)	Surg: 63% (46 of 73) MT: 57% (20 of 35) *P*= .67	78% (39 of 50)

OUTCOME	TEEN-LABS/ TODAY N = 93 2 YEARS	TEEN-LABS N = 242 3 YEARS	AMOS N = 162 5 YEARS	FABS-5+ N = 58 5 TO 12 YEARS
Low iron or ferritin	NR	57% (98 of 171)	Surg: 66% (51 of 77) MT: 29% (12 of 42) $P < .001$	63% (32 of 51)
Anemia	NR	NR	Surg: 32% (25 of 77) MT: 7% (3 of 42) $P = .001$	NR

Abbreviations. AMOS: Adolescent Morbid Obesity Surgery; ED: emergency department; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; MT: medical therapy; NR: not reported; Surg: bariatric surgery, any type; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

Perioperative complications were reported in 2 adolescent studies (Table 24).[61,62] In the Teen-LABS study, most perioperative complications (47 of 67 events) were deemed to be minor (i.e., non-life-threatening or requiring invasive intervention) and almost all events occurred and resolved prior to hospital discharge.[61] In the AMOS study, 14 participants in the surgical study group (17%) had a major perioperative event, of which 12 were related to hernia repair or gall bladder removal and 2 were due to suicide attempts in 2 separate participants.[62] Eight minor events also occurred, 4 of which were related to the need for further psychiatric care or evaluation.[62]

Additional abdominal surgeries were the most common long-term AEs and occurred in 12% to 40% of surgical participants.[24,61-63] The majority of these procedures were cholecystectomies (gall bladder removal surgeries) or hernia repair. Reoperations or revisions to the primary bariatric procedures were not widely reported. Other long-term adverse events included outpatient endoscopic procedures for upper gastrointestinal issues (13% to 22%) and anemia-related blood transfusions (2% to 3%).[24,61-63] Deaths were uncommon, with only 5 reported deaths occurring over 12 years of follow-up among the 525 enrolled study participants.[24,71] No deaths were related to bariatric surgery; however, 2 deaths were attributed to drug overdose.[24] Notably, 7% of surgical participants in the AMOS study were referred for inpatient psychiatric evaluation related to exacerbations of pre-existing depression or anxiety disorders.[71]

Reported rates of nutritional abnormalities in adolescents with bariatric procedures were high (Table 24; Appendix D, Table D9), with up to 66% having low iron or ferritin levels and up to 78% having vitamin D deficiency at 5 or more years post-surgery.[24,66,71] In the AMOS study, almost a third of participants (32%) were found to have clinical anemia. Moreover, comparison of with medical therapy participants showed that rates of low vitamin B12, low iron or ferritin, and clinical anemia were significantly higher among adolescents who received bariatric surgery.[71] These findings highlight the need for adherence to postsurgical monitoring and supplementation therapy in this population.

Ongoing Studies

We identified 2 ongoing clinical trials of bariatric surgery in adolescents.

The Adolescent Morbid Obesity 2 (AMOS2) trial is an RCT comparing bariatric surgery (i.e., RYGB or SG) with intensive non-surgical medical therapy for the treatment of severe obesity (i.e., BMI > 35) in 50 Swedish adolescents aged 13 to 16 years.[78] Participants were recruited from 3 tertiary childhood obesity treatment clinics across Sweden where they had undergone at least 1 year of unsuccessful comprehensive medical therapy for obesity.[78] The primary study outcome is changes in BMI and secondary outcomes include incidence of cardiovascular illness and cancer, biochemical markers of metabolic health, body composition, bone health, physical fitness, quality of life, and psychological and cognitive functioning.[78] The trial is initially planned for 2 years of follow-up and completed primary data collection in June 2022; additional follow-up is planned for 5, 10, and 15 years from baseline.[78]

The Bariatric Surgery in Children (BASIC) trial is an RCT comparing adjustable gastric banding with intensive nonsurgical medical therapy for the treatment of severe obesity (i.e., BMI > 40) in 60 Dutch adolescents aged 14 to 16 years.[79] Although study investigators acknowledge the evidence supporting greater treatment effectiveness with other forms of bariatric surgery, gastric banding was selected as the primary bariatric intervention due to the reversibility of the procedure, thereby allowing participants to seek more permanent interventions in the future.[79] Eligible study participants had to complete at least 1 year of unsuccessful intensive lifestyle intervention for obesity after which they were referred for treatment at a single university medical center in The Netherlands.[79] Primary study outcomes are percent total weight loss and change in BMI, secondary outcomes include body composition, pubertal development, metabolic and endocrine changes, inflammatory status, cardiovascular abnormalities, non-alcoholic hepatitis, quality of life, and changes in behavior.[79] Follow-up visits are planned for 6 months, 1, 2, and 3 years; primary data collection was completed in December 2022.[79]

Evidence Summary

There is a robust evidence base from systematic reviews of RCTs and large comparative cohort studies supporting the use of bariatric procedures in adults who meet the current NIH criteria (i.e., BMI ≥ 35 kg/m^2 with comorbidities or BMI ≥ 40 kg/m^2 with or without comorbidities), but data are less clear regarding the effectiveness and harms of bariatric procedures for adults with BMI 30.0 to 34.9 kg/m^2, with the least evidence for adolescents with obesity. In the following summaries, low and very-low levels of confidence indicate that if new information from additional studies were published, our understanding of the effectiveness and harms of bariatric procedures for those populations is likely to change.

For Adults with BMI of 35 kg/m^2 or Greater:

- We have high confidence that bariatric procedures are positively associated with clinically significant weight reduction and result in significantly greater weight loss compared with medical therapies for obesity.
- We have moderate confidence that bariatric procedures reduce all-cause mortality compared with medical therapies for obesity.
- We have very low to moderate confidence that, compared with medical therapy, bariatric procedures are associated with the improvement or resolution of certain comorbidities, such as T2DM, HTN, and CAD.
- We have low confidence that bariatric procedures are associated with significantly greater improvement in overall and condition-specific QoL compared with medical therapy.
- We have low confidence that bariatric procedures are not associated with a significant difference in nonsurgical adverse events compared with medical therapy. Overall, bariatric procedures are associated with low rates of perioperative morbidity and mortality but may result in the need for surgical revision or reintervention over time.

- We did not identify any evidence regarding the effectiveness of bariatric procedures for treating obstructive sleep apnea, joint arthropathy, or intracranial HTN.

For Adults with BMI 30.0 to 34.9 kg/m^2:

- Available evidence in this population is limited to adults with T2DM.
- We have moderate confidence that bariatric procedures are associated with clinically significant BMI reduction and results in significantly greater percent weight loss compared with medical therapies for obesity.
- We have low confidence that bariatric procedures are associated with clinically significant HbA1c reduction and results in higher rates of T2DM remission compared with medical therapy interventions.
- We have very low confidence regarding the effect of bariatric procedures on the improvement or resolution of HTN. There was mixed evidence, with some studies indicating BP improvements and HTN resolution, and some evidence for no between-group differences.
- We have very low confidence regarding the effect of bariatric procedures on the improvement of CAD-related outcomes. There was mixed evidence regarding the impact of bariatric surgery on LDL-C and triglycerides levels, and no evidence of effect on the use of medications to treat or prevent heart disease.
- We have very low confidence that bariatric procedures are associated with low rates of AEs, serious AEs, and nutritional abnormalities.
- We did not identify any evidence regarding the effectiveness of bariatric procedures for all-cause mortality, OSA, joint arthropathy, or intracranial HTN.

For Adolescents with Obesity:

- We have low confidence that bariatric procedures are associated with short- and long-term weight reduction and result in greater weight loss compared with medical therapies.
- We have very low confidence that bariatric procedures are associated with substantial reductions in T2DM, elevated BP, and elevated markers of heart disease risk, but there is some mixed evidence based on continuous measures that may indicate that surgery patients do not have significantly different outcomes compared with medical therapy.
- We have very low confidence that bariatric procedures may be associated with a decrease in joint arthropathy as indicated by reduced musculoskeletal pain during physical activity over time.
- We have very low confidence that bariatric procedures are associated with improvements in weight-related QoL, but they may have a limited differential effect from medical therapy in terms of other physical or behavioral QoL outcomes.
- We have very low confidence that mortality after bariatric procedures is rare in adolescents, but rates of vitamin insufficiencies are relatively high.
- We did not identify any evidence regarding the effectiveness of bariatric procedures for all-cause mortality, sleep apnea, or intracranial HTN.

Despite the wide range of studies analyzed in our included reviews, we did not identify eligible clinical evidence for several key interventions and outcomes for this review including intragastric balloons, the SADI-S procedure, and the effect of bariatric procedures on OSA, joint arthropathy in adults, or intracranial HTN. Although we identified several reviews evaluating the efficacy and safety of intragastric balloons, the primary studies included did not have sufficient length of follow-up for inclusion in our review (i.e., ≥ 12 months). We also identified reviews regarding the efficacy and safety of SADI-S[80] and the effect of bariatric procedures on obstructive sleep apnea[81]; however, in both instances the primary studies were small (i.e., N < 500), uncontrolled case series, or case studies; therefore, none of these studies met our sample size or study design criteria for inclusion.

Limitations in the available evidence include inconsistent or incomplete data reporting. Many outcomes were assessed using multiple measures or outcome definitions (e.g., mean weight loss vs. % excess weight loss), which limited estimations of magnitude of effect for the key outcomes and between population groups. Additionally, outcome data were rarely stratified by control conditions, thereby limiting our ability to understand the effect of bariatric procedures against certain types of medical interventions (e.g., pharmacology vs. lifestyle interventions). Similarly, the included studies largely did not report outcomes stratified by populations that have experienced historical inequities outlined in our scope statement (e.g., race or ethnicity, surgical setting). Finally, statistical methods were inconsistent across included systematic reviews for adults with BMI 35 or greater resulting in lower confidence ratings for some outcomes due to concerns over precision.

POLICY LANDSCAPE

In the following section, we summarize public and private payer policies, clinical guidance from professional societies, and policy statements about bariatric procedures for the treatment of obesity. Table 25 presents a high-level summary of coverage criteria for bariatric procedures across policies and guidance documents, and the text section details differences between policies and published guidance and other details relevant to the treatment of obesity with bariatric procedures.

Table 25. Criteria for Candidate Selection from Clinical Practice Guidelines and Payer Coverage Policies

PATIENT CHARACTERISTICS	ASMBS/ IFSO	AAP	AACE/TOS/ ASMBS/ OMA/ASA	EAES, IFSO-EC, EASO, ESPCOP	Canadian Adult Obesity	NICE	MEDICARE NCD	Aetna, Cigna, Moda, RBCBS	Washington Medicaid (Apple Health)
ADULT POPULATIONS (18 years of age or older)									
≥ 40 BMI with or without comorbidities	✓	NA	✓	✓	✓	✓	X[d]	✓	✓
≥ 35 BMI and one or more severe obesity-related complications remediable by weight loss[a]	X	NA	✓	✓	✓	✓	✓	✓	✓
≥ 35 BMI with or without comorbidities	✓	NA	X	X	X	X	X	X	X
30 to 34.9 BMI plus T2DM or other uncontrolled comorbidities	✓[b]	NA	✓	✓	✓	X	X	X	✓
Requires non-surgical interventions first	X	NA	X	X	X	✓	✓	✓	X
PEDIATRIC POPULATIONS (10 to 19 years of age)									
Class III obesity (140% of the 95th percentile)	✓	✓	NA	NA	NA	X[e]	NA	✓	X[g]
Class II obesity (120% of the 95th percentile) plus a comorbidity[c]	✓	✓	NA	NA	NA	X[e]	NA	✓	X
No current or planned pregnancy within 12 to 18 months of surgery	✓	✓	NA	NA	NA	NA	NA	X	NA
Multidisciplinary care	✓	✓	NA	NA	NA	NA[f]	NA	✓	NA

Table Key. A check indicates that the criterion is endorsed. An X indicates that the criterion is not or not fully endorsed. NA indicates that the associated recommendation or policy does not apply to the specified population.

Notes. [a] For example, T2DM, poorly controlled hypertension, osteoarthritis, or obstructive sleep apnea.[2] [b] Joint ASMBS and IFSO guidelines issued in 2022 recommend bariatric surgery for individuals with BMI 30 to 34.9 in the absence of substantial weight loss or control of any obesity-related comorbidities with nonsurgical therapy.[20] [c] For example, depressed health-related quality of life score, T2DM, or obstructive sleep apnea.[20] [d] Medicare requires the beneficiary have at least 1 comorbidity regardless of BMI.[82] [e] NICE guidelines state that bariatric surgery is generally not recommended in young people and may only be considered in exceptional circumstances. [f] Bariatric surgery in young people should only be undertaken by a multidisciplinary team. [g] Bariatric surgery is not covered for Washington Medicaid beneficiaries aged < 18 years.

Abbreviations. AACE/TOS/ASMBS/OMA/ASA: American Association of Clinical Endocrinologists/American College of Endocrinology, the Obesity Society, American Society for Metabolic & Bariatric Surgery, Obesity Medicine Association, and American Society of Anesthesiologists; AAP: American Academy of Pediatrics; ASMBS: American Society for Metabolic and Bariatric Surgery; BMI: body mass index; EAES: European Association for Endoscopic Surgery; EASO: European Association for the Study of Obesity; ESPCOP: European Society for the Peri-operative Care of the Obese Patient; IFSO-EC: International Federation for the Surgery of Obesity and Metabolic Disorders; NA: not applicable; NICE: National Institute for Health and Care Excellence; RBCBS: Regence BlueCross BlueShield; T2DM: type 2 diabetes mellitus.

Evidence-based Recommendations

We identified 8 clinical practice guidelines that reviewed substantial published literature regarding studies of bariatric procedures and provided recommendations for patient selection and care; 5 guidelines had good methodological quality,[2,3,83-85] 2 guidelines had fair methodological quality,[20,80] and 1 guideline had poor methodological quality (see Appendix C for guideline methodologic quality assessment criteria).[46] The general criteria for candidate selection are summarized in Table 25, alongside the criteria from payer coverage policies.

The majority of guidelines we identified that made recommendations for adult populations agreed about the following criteria for candidates for bariatric surgery[2,3,83-86]:

- Individuals with BMI 40 or greater, with or without comorbidities
- Individuals with BMI 35 to 40, with at least 1 severe obesity-related comorbidity
- Individuals with BMI between 30 and 35, with poorly controlled T2DM or poorly controlled HTN

Organizations that supported the guideline publications in which those criteria were presented include:

- Obesity Canada
- The Canadian Association of Bariatric Physicians and Surgeons
- American Diabetes Association
- European Association for Endoscopic Surgery
- European Chapter of the International Federation for the Surgery of Obesity
- European Association for the Study of Obesity
- European Society for Perioperative Care of the Obese Patient
- American Association of Clinical Endocrinologists
- American College of Endocrinology
- The Obesity Society
- Obesity Medicine Association
- American Society of Anesthesiologists
- American Academy of Sleep Medicine

In contrast, a joint guideline issued in 2022 by the American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) recommended bariatric procedures for less highly selected populations of adults[20]:

- Individuals with BMI 35 or greater, with or without comorbidities
- Individuals with BMI between 30 and 34.9 who do not achieve sustained weight loss or control of obesity-related comorbidities using nonsurgical methods

The ASMBS/IFSO guidelines additionally recommend that bariatric interventions be considered for Asian populations with BMI ≥ 25 and for older adults with obesity after careful consideration of the benefits and risks, with no upper age limit.[20]

Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures were published in 2019, and were cosponsored by American Association of Clinical Endocrinologists/American College of Endocrinology, the Obesity Society, American Society for Metabolic & Bariatric Surgery, Obesity Medicine Association, and American Society of Anesthesiologists (AACE/TOS/ASMBS/OMA/ASA).[2] This publication presented 85 recommendations related to the selection of candidates for bariatric surgery through each step of their clinical care.[2] We assessed this publication as having good methodological quality. This publication additionally recommended that BMI ranges be adjusted for individuals identified as Asian race or ethnicity (i.e., BMI 25 or greater indicates obesity).[2]

Adults with BMI 30.0 to 34.9 kg/m^2

The 2022 joint ASMBS/IFSO guidelines on indications for bariatric surgery recommended consideration of bariatric surgery for individuals with BMI 30.0 to 34.9 who do not achieve substantial or sustained weight loss or improvement of obesity-related comorbidities.[20] These guidelines largely align with the position statement issued by the ASMBS in 2018, with the exception that no upper age restrictions are recommended.[46] We rated this publication as having fair methodological quality by the standards that we use for clinical practice guidelines.

The 2018 ASMBS position statement additionally reviewed the current positions related to BMI 30.0 to 34.9 for top health care organizations, and noted that the following organizations support bariatric surgery for adults with BMI 30.0-34.9 when the individual also has a significant obesity-related comorbidity (e.g., poorly controlled T2DM, poorly controlled HTN):

- International Diabetes Federation and the American Diabetes Association
- National Institute for Health and Care Excellence

Adolescents

The ASMBS pediatric metabolic and bariatric surgery guidelines were published in 2018.[87] We rated this publication as having fair methodological quality primarily due to incomplete reporting of methods and a lack of integration of RoB of the evidence upon which the recommendations were based. For adolescents, ASMBS recommended that individuals with BMI 35.0 to 39.9 plus a severe comorbidity (e.g., cardiovascular disease, T2DM, OSA), or BMI greater than 40 and a less severe morbidity, be considered for bariatric surgery.[87] As described earlier in this coverage guidance, the ASMBS recommended that candidates for bariatric surgery be referred to clinics accredited by the MBSAQIP and receive coordinated care from a multidisciplinary team.[87] The publication also noted implications of bariatric surgery for future pregnancies; overall, there appears to be a benefit for both mother and infant, but there are risks for infant development if vitamin supplementation is inadequate after bariatric surgery.[87]

The American Academy of Pediatrics (AAP) published a policy statement and supporting evidence review detailing the selection and care of adolescent candidates for bariatric procedures in 2019; the criteria closely align with those described by the ASMBS above.[26] In 2023, the AAP issued its first clinical practice guideline for the evaluation and treatment of children and adolescents with obesity.[88] We rated this publication as having fair methodologic quality due to incomplete reporting of methods. The guideline recommended that pediatricians and other pediatric primary care clinicians offer referrals to adolescents aged 13 years and older with severe obesity (BMI ≥ 120% of the 95th percentile for age and sex) for evaluation at comprehensive multidisciplinary pediatric metabolic and bariatric surgery centers.[88] Given the lack of available comparative evidence from high-quality study designs, the guideline authors chose to issue a recommendation for evaluation, rather than recommend surgery as a standard treatment for severe adolescent obesity outright.[88]

The joint ASMBS/IFSO guidelines also align with the previously established ASMBS and AAP selection criteria.[20] In addition, the guidelines assert that bariatric procedures have not been shown to negatively affect puberty or growth and, therefore, do not recommend a specific Tanner or bone development stage as criteria for surgery.[20] The guidelines also suggest that syndromic obesity, developmental disabilities, and history of trauma should be considered during candidate selection, but should not be used as strict contraindications for bariatric procedures. [20]

Guidelines Addressing Specific Procedures or Approaches

The European Association for Endoscopic Surgery Bariatric Guidelines Group published a consensus document based on a systematic review and network meta-analysis of head-to-head trials of different bariatric surgical procedures in 2022.[85] We assessed this publication as having good methodological quality. In the version of the guideline written for lay audiences, there are also decision aids for selecting appropriate bariatric procedures.[89] Given the evidence review and network meta-analysis, the conclusions of the guideline committee ranked SG and RYGB as preferred interventions, followed by OAGB and SADI-S.[85] However, the committee also stated that individual patient characteristics, values, preferences, other comorbid conditions, and surgeon preference and expertise should inform the selection of bariatric procedure.[85]

The IFSO published a literature review and position statement in 2020 regarding single anastomosis duodenal-ileal bypass with sleeve gastrectomy/one anastomosis duodenal switch (SADI-S/OADS).[80] We rated this publication as having fair methodological quality. The authors concluded that SADI-S/OADS is effective for weight loss and improvement in metabolic health in the medium term, but that long-term safety studies indicated nutritional deficiencies in individuals after this procedure.[80] The publication additionally noted that evidence from RCTs for safety and efficacy was lacking.[80]

The Canadian Adult Obesity Clinical Practice Guideline for bariatric surgery noted that procedure selection should be tailored to the patient's needs and preferences, but that laparoscopic approach should be standard.[3]

Payer Coverage Policies

We identified policies related to covering bariatric surgery from Aetna, Cigna, and Regence BlueCross BlueShield, Moda, the Washington Medicaid program, and a national coverage determination for Medicare. All of these policies consider IGBs to be experimental or investigational, and the interventional procedures guidance published in 2020 by the National Institute for Heal and Care Excellence stated that the evidence was inadequate to support efficacy for swallowable gastric balloon capsules for weight loss.[90]

Medicaid

The Washington State Health Care Authority Health Technology Clinical Committee made a coverage determination about bariatric surgery after an evidence review completed in 2015[91] and the following determination related to bariatric surgery.

For patients age ≥ 18 years of age bariatric surgery is covered for the following conditions[92]:

- BMI ≥ 40
- BMI 35 to < 40 for those patients with at least one obesity-related co-morbidity
- BMI 30 to < 35 with T2DM
- When covered, patients must abide by all other agency surgery program criteria (e.g., using specified centers or practitioners; completing a pre-operative psychological evaluation; participating in pre- and post-operative multidisciplinary care programs)

Bariatric surgery is not covered for patients who are under the age of 18 years, have a BMI under 30, or have a BMI of 30 to 35 without T2DM.[92]

Medicare

We identified 1 national coverage determination for Medicare related to bariatric surgery.[82] We did not identify an additional local coverage determination for contractors with Medicare clients in Oregon.

The national coverage guidance requires[82]:

- The beneficiary has a BMI of 35 or more; at least 1 comorbidity (e.g., T2DM); ruled out disease-causing obesity (e.g., Cushing disease); and have documentation that the beneficiary tried non-surgical medical treatment unsuccessfully
- Covered procedures include open and laparoscopic RYGB, open and laparoscopic BPD/DS or Gastric Reduction Duodenal Switch (BPD/GRDS), or laparoscopic AGB
- The facility be a Medicare-approved Center of Excellence

The national coverage determination additionally specifies that the following are not covered: bariatric surgery for the treatment of obesity alone, open adjustable gastric banding, open SG, open and laparoscopic vertical banded gastroplasty, intestinal bypass surgery, and gastric balloon for treatment of obesity.[82]

Private Payers

Coverage criteria for bariatric procedures was similar across the 4 private payers, and a summary of those criteria is in Table 25. To summarize, these policies indicated coverage of bariatric surgery for individuals with BMI of 40 or greater for primary obesity, and for individuals with BMI of 35 or greater who additionally have a serious obesity-related comorbidity.

Each policy detailed slightly different requirements (e.g., lengths of time, type of documentation) for a pre-surgery, structured intervention overseen by medical professionals for weight loss. In general, the beneficiary is required to have failed to lose a clinically important amount of weight during the course of that intervention prior to being eligible for a bariatric surgery.[93-96]

Policies also varied on whether revisions or reoperations were covered: Moda did not cover any revision, but Aetna, Regence BlueCross BlueShield, and Cigna all covered revisions and reoperations for either development of complications or medical necessity resulting from a failure to lose sufficient weight.[93-96]

In contrast to the Washington Health Technology Assessment coverage determination, the policies for Aetna and Cigna considered bariatric surgery as a treatment for T2DM in patients with a BMI less than 35 to be investigational and experimental.[93,96]

The coverage policy for Cigna stated that an altered threshold for BMI be used for individuals whose providers attest they are of Asian race or ethnicity with a BMI of 37.5 or greater without a comorbidity, or a BMI of 32.5 or greater with a comorbidity.[96]

Common examples of contraindications for bariatric surgery included an ongoing substance use disorder, medically correctable cause of obesity, inability to adhere to post-operation care and lifestyle requirements (determined from psychiatric or medical assessment), or current pregnancy (or pregnancy planned within a year of the operation).

Adolescents

Policies related to bariatric procedures for adolescents, defined as individuals between 10 and 19 years of age by the World Health Organization,[97] had different eligibility criteria than policies for adults. Each policy included a requirement about assessing the skeletal maturity of the individual prior to surgery.[93-96] The Regence BlueCross BlueShield policy required documentation of Tanner 4 or 5 pubertal development,[94] although the ASMBS recommendations for assessing eligibility in pediatric populations states that there is no evidence that bariatric surgery has negative effect on puberty or linear growth.[87]

These policies generally required that adolescents have either[93-96]:

- BMI exceeding 40 with at least 1 serious comorbidity (e.g., OSA, T2DM), or
- BMI exceeding 50 with a less serious comorbidity (e.g., medically refractory HTN, obesity-related psychosocial distress, gastroesophageal reflux disease)

Similar to policies for adults, the adolescents are required to have documentation of having attempted weight loss without significant reduction under the supervision of an intensive multicomponent intervention.

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APPENDIX A. GRADE TABLE ELEMENT DESCRIPTIONS

Table A1. GRADE Table Elements

ELEMENT	DESCRIPTION
Balance of benefits and harms	The larger the difference between the desirable and undesirable effects, the higher the likelihood that a strong recommendation is warranted. An estimate that is not statistically significant or has a confidence interval crossing a predetermined clinical decision threshold will be downgraded.
Quality of evidence	The higher the quality of evidence, the higher the likelihood that a strong recommendation is warranted.
Resource allocation	The higher the costs of an intervention—that is, the greater the resources consumed in the absence of likely cost offsets—the lower the likelihood that a strong recommendation is warranted.
Values and preferences	The more values and preferences vary, or the greater the uncertainty in values and preferences, the higher the likelihood that a weak recommendation is warranted.
Other considerations	Other considerations include issues about the implementation and operationalization of the technology or intervention in health systems and practices within Oregon.

Abbreviation. GRADE: Grading of Recommendations, Assessment, Development, and Evaluations.

Confidence in Estimate Rating Across Studies for the Intervention and Outcome

Assessment of confidence in estimate includes factors such as risk of bias, precision, directness, consistency, and publication bias.

High: The subcommittee is very confident that the true effect lies close to that of the estimate of the effect. Typical sets of studies are randomized controlled trials (RCTs) with few or no limitations, and the estimate of effect is likely stable.

Moderate: The subcommittee is moderately confident in the estimate of effect: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Typical sets of studies are RCTs with some limitations or well-performed nonrandomized studies with additional strengths that guard against potential bias and have large estimates of effects.

Low: The subcommittee's confidence in the estimate of effect is limited: The true effect may be substantially different from the estimate of the effect. Typical sets of studies are RCTs with serious limitations or nonrandomized studies without special strengths.

Very low: The subcommittee has very little confidence in the estimate of effect: The true effect is likely to be substantially different from the estimate of effect. Typical sets of studies are nonrandomized studies with serious limitations or inconsistent results across studies.

APPENDIX B. GRADE EVIDENCE PROFILES

Table B1. Certainty Assessment (Confidence in Estimate of Effect) for Adults with BMI ≥ 35 kg/m^2

SUB-OUTCOME	NO. OF STUDIES	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
All-cause Mortality							
--	3 reviews with 19 comparative cohort studies	High	Not serious	Not serious	Not serious	None	Moderate ●●●○
Weight Change							
--	5 reviews with 36 RCTs and 5 observational studies	Low	Not serious	Not serious	Not serious	None	High ●●●●
Improvement or Resolution of Chronic Conditions							
Diabetes	5 reviews with 28 RCTs	Low	Not serious	Serious Remission definitions varied across studies	Not serious	Most robust estimates come from a network meta-analysis	Moderate ●●●○
Hypertension	3 reviews with 20 RCTs and 2 comparative cohort studies	Low	Serious	Serious	Not serious	Most robust estimates come from a network meta-analysis	Low ●●○○
Coronary Artery Disease	2 reviews of 7 RCTs and 6 comparative cohort studies	High	Not serious	Serious	Not serious	Some results based on composite outcomes	Low ●●○○
Sleep Apnea	0						No evidence ○○○○
Joint Arthropathy	0						No evidence ○○○○
Intracranial Hypertension	0						No evidence ○○○○
Quality of Life							
--	2 SRs including 8 RCTs and 6 observational studies	High	Not serious	Serious	Not serious	Some analyses based on indirect analysis of a proxy measure	Low ●●○○
Harms							

SUB-OUTCOME	NO. OF STUDIES	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
--	6 reviews with 40 RCTs and 67 observational studies	High	Serious	Not serious	Not serious	None	Low ●●○○

Abbreviations. BMI: body mass index; kg/m^2: kilograms per meters squared; No.: number; RCT: randomized controlled trial; SR: systematic review.

Table B2. Certainty Assessment (Confidence in Estimate of Effect) for Adults with BMI 30 to 34.9 kg/m^2

SUB-OUTCOME	NO. OF STUDIES	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
All-cause Mortality							
--	0						No evidence ○○○○
Weight Change							
--	5 RCTs N = 391	Moderate Most studies rated as moderate due to imbalances in some baseline demographics and significant attrition in control groups	Not serious Direction and magnitude of effect is the same across studies and across study timepoints	Not serious 2 studies conducted in lower-income non-US countries; several studies included participants above and below the target BMI range, but had qualifying mean BMIs	Not serious Reasonable sample size and confidence intervals in pooled analyses are not overly wide	None	Moderate ●●●○
Improvement or Resolution of Chronic Conditions							
Diabetes	6 RCTs N = 433	Moderate Most studies rated as moderate due to imbalances in some baseline demographics and significant attrition in control groups	Not serious Direction and magnitude of effect is the same across studies and across study timepoints	Serious Multiple definitions for T2DM remission were used across studies	Not serious Good sample size and wide confidence intervals in remission estimates, but those estimates are supported by significantly lower and highly precise HbA1c values	None	Low ●●○○
Hypertension	5 RCTs N = 391	Moderate Most studies rated as moderate due to imbalances in some baseline demographics and significant attrition in control groups	Serious Differences in both mean SBP and mean DBP varied across follow-up timepoints and even within studies	Not serious Also, definitions of HTN did not vary between studies	Serious Several timepoints in the MAs of mean SBP and DBP only had 1 contributing study (low sample sizes), and similarly, several additional outcomes were based on single study estimates	Some selective reporting present (DBP-related results not as widely reported as SBP, even when DBP was collected at baseline)	Very low ●○○○

SUB-OUTCOME	NO. OF STUDIES	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
Coronary Artery Disease	5 RCTs N = 391	Moderate Most studies rated as moderate due to imbalances in some baseline demographics and significant attrition in control groups	Serious Mixed results within and between CDV outcomes	Serious All outcomes were intermediate measures of CAD (e.g., LDL-C levels, medication use) vs. direct cardiac events or diagnoses	Serious Confidence intervals and standard deviations were fairly wide due to small sample sizes contributing to lab values	None	Very low ●○○○
Sleep Apnea	0						No evidence ○○○○
Joint Arthropathy	0						No evidence ○○○○
Intracranial Hypertension	0						No evidence ○○○○
Quality of Life							
--	1 RCT N = 100	Moderate 1 moderate ROB study due to imbalances in key baseline chars (surgery group more likely to be white and take lipid lowering medications); adjustment for these imbalances is not widely applied	Not assessable Only 1 study available	Serious Single RCT conducted entirely in Brazil among patients with both T2DM and chronic kidney disease; may make results less generalizable to class I US populations	Serious Confidence intervals and standard deviations were fairly wide (much larger than MID of 2 to 3 points) due to small sample size	None	Very low ●○○○
Harms							
--	5 RCTs N = 391	Moderate Most studies rated as moderate due to imbalances in some baseline demographics and significant attrition in control groups	Serious Much higher rates of SAE in 1 trial, virtually none in other trials	Serious Unclear if the same types of events were considered for AE vs. SAE	Serious Low event rates with no standardized calculations. Only 1 study assessed nutritional deficiencies.	None	Very low ●○○○

Abbreviations. AE; adverse events; BMI: body mass index; CAD: coronary artery disease; DBP: diastolic blood pressure; kg/m^2: kilograms per meters squared; LDL-C: low-density lipoprotein cholesterol; MA: meta-analysis; RCT: randomized controlled trial; RoB: risk of bias; SAE: serious adverse events; SBP: systolic blood pressure; T2DM: type 2 diabetes mellitus.

Table B3. Certainty Assessment (Confidence in Estimate of Effect) for Adolescents

SUB-OUTCOME	NO. OF STUDIES	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
All-cause Mortality							
--	0						No evidence ○○○○
Weight Change							
--	4 cohort studies N = 525	High Studies rated as moderate to high due to imbalances in study groups at baseline and lack of adjustment for confounders	Not serious	Serious 2 studies were noncomparative and 1 study used a matched medical therapy comparator group from another trial	Not serious	None	Low ●●○○
Improvement or Resolution of Chronic Conditions							
Diabetes	4 cohort studies N = 525	High Studies rated as moderate to high due to imbalances in study groups at baseline and lack of adjustment for confounders	Serious Conflicting results in terms of HbA1c reduction (improved with surgery at 2 years but no difference vs. MT at 5 years)	Serious 2 studies were noncomparative and 1 study used a matched medical therapy comparator group from another trial	Serious Few observed events in some studies (very few events in reported control groups), and adjusted results were not reported for all studies	None	Very low ●○○○
Hypertension	4 cohort studies N = 525	High Studies rated as moderate to high due to imbalances in study groups at baseline and lack of adjustment for confounders	Serious Comparative results for mean SBP and DBP were mixed across studies	Not serious	Serious Few observed events in some studies (very few events in reported control groups), and adjusted results were not reported for all studies	None	Very low ●○○○
Coronary Artery Disease	2 cohort studies N = 255	Moderate 1 study rated as moderate due to slight differences between groups at baseline	Serious Conflicting results between comparative studies in both mean LDL-C and mean triglycerides	Serious Elevated LDL-C and/or triglycerides are intermediate measures associated with higher risk for coronary artery disease, but are not direct	Serious Few observed events in some studies (very few events in reported control groups), and adjusted results were not reported for all studies	None	Very low ●○○○

SUB-OUTCOME	NO. OF STUDIES	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
				evidence of CAD (e.g., cardiac events).			
Sleep Apnea	0						No evidence ○○○○
Joint Arthropathy	1 cohort study N = 206	Moderate 1 moderate RoB study due to lack of a nonsurgical comparator group and low completion of relevant follow-up visits (53%)	Not assessable	Serious Looked at self-reported rates of musculoskeletal pain during walk tests, not diagnosed arthropathies, but seems like an appropriate joint outcome for adolescents	Serious Small sample size: only based on self-reported pain in about 50 (of 206) participants	None	Very low ●○○○
Intracranial Hypertension	0						No evidence ○○○○
Quality of Life							
--	2 cohort studies N = 395	Moderate 2 moderate RoB studies due to lack of medical therapy comparator group and imbalances in some critical baseline characteristics between study groups	Serious Consistent weight-specific benefits within surgical groups (despite the use of differing scales), but no difference when compared with medical therapy controls Mixed results in general QoL domains assessed by SF-36 survey	Not serious	Serious Wide confidence intervals/SDs in some of the SF-36 domains (e.g., mean 50.8 points, SD 23 points on a 100-point scale)	None	Very low ●○○○
Harms							
--	4 cohort studies N = 525	High Studies rated as moderate to high due to imbalances in study groups at baseline and lack of adjustment for confounders					Very low ●○○○

Abbreviations. AE; adverse events; BMI: body mass index; CAD: coronary artery disease; DBP: diastolic blood pressure; kg/m^2: kilograms per meters squared; LDL-C: low-density lipoprotein cholesterol; MA: meta-analysis; MT: medical therapy; QoL: quality of life; RCT: randomized controlled trial; RoB: risk of bias; SAE: serious adverse events; SBP: systolic blood pressure; SD: standard deviation; SF-36: Short Form-36 survey; T2DM: type 2 diabetes mellitus.

APPENDIX C. METHODS

Scope Statement

Populations

Adults and adolescents with obesity (body mass index [BMI] ≥ 30) who are being considered for bariatric procedures

Population scoping notes: Exclude non-obese populations (BMI < 30)

Interventions

Bariatric procedures, for example, adjustable gastric banding, Roux-en-Y gastric bypass (RYGB), biliopancreatic diversion with duodenal switch (BPD/DS), vertical sleeve gastrectomy (VSG), single anastomosis duodenal-ileal bypass with sleeve gastrectomy (SADI-S), and intragastric balloons (IGB)

Intervention exclusions: Bariatric devices that are not approved by the US Food and Drug Administration (FDA) or not available in the United States

Comparators

Nonsurgical treatment (e.g., medical management, pharmacotherapy, intensive multicomponent behavioral interventions, behavioral counseling, structured weight management programs, other devices or procedures, or combinations of these therapies)

Outcomes

Critical: All-cause mortality

Important: Clinically significant improvement or resolution of chronic disease, weight change, quality of life, or harms

Considered but not selected for the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) table: Specific chronic diseases (e.g., arthritis, sleep apnea) or changes in healthcare utilization

Key Questions

The following Key Questions (KQs) guided our research for the present report:

KQ1. What is the effectiveness of bariatric procedures for the treatment of obesity in adults and adolescents as compared to other treatments?

KQ2. What are the harms of bariatric procedures for the treatment of obesity in adults and adolescents?

KQ3. Is there evidence of differential effectiveness or harms for bariatric procedures by:

- a. Age
- b. Sex
- c. Race/ethnicity
- d. BMI category
- e. Comparator
- f. Whether the patient has received prior bariatric surgery
- g. Comorbidities (e.g., medical, behavioral health, other disabilities)

h. Site of procedure (inpatient vs outpatient surgical center, centers of excellence vs not)
i. Time since procedure

Contextual Questions

CQ1. What kinds of accreditation standards and center of excellence designations exist in the United States and what are the requirements of each?
CQ2. What is the appropriate minimum age or developmental stage for bariatric surgery?

Search Strategy

A full search of the core sources was conducted to identify systematic reviews, meta-analyses, randomized controlled trials, cohort studies, and health technology assessments that meet the criteria for the scope described above. Searches of core sources were limited to citations published after 2019, although key publications prior to this date range were sought for the pediatric population.

The following core sources were searched:

- Agency for Healthcare Research and Quality (AHRQ)
- Canadian Agency for Drugs and Technologies in Health (CADTH)
- Cochrane Library (Wiley Online Library)
- Institute for Clinical and Economic Review (ICER)
- National Institute for Health and Care Excellence (NICE)
- Veterans Administration Evidence-based Synthesis Program (ESP)
- Washington State Health Technology Assessment Program

A MEDLINE search was also conducted to identify systematic reviews, meta-analyses, randomized controlled trials (RCTs), cohort studies, and health technology assessments. For systematic reviews and meta-analyses, the search was limited to publications in English published since 2019. For randomized controlled trials and cohort studies, the search was limited to publications in English published since 2012.

Searches for clinical practice guidelines were limited to those published since 2019. A search for relevant clinical practice guidelines was also conducted using MEDLINE and the following sources:

- Canadian Agency for Drugs and Technologies in Health (CADTH)
- Centers for Disease Control and Prevention (CDC)
- Community Preventive Services
- National Institute for Health and Care Excellence (NICE)
- Scottish Intercollegiate Guidelines Network (SIGN)
- United States Preventive Services Task Force (USPSTF)
- Veterans Administration/Department of Defense (VA/DoD) Clinical Practice Guidelines

Inclusion/Exclusion Criteria

Studies were excluded if they were not published in English, did not address the scope statement, or were study designs other than systematic reviews or meta-analyses with RCTs (or comparative cohort studies for adolescents), or clinical practice guidelines. We required that studies have a minimum of 1 year of follow-up for effectiveness outcomes, or any amount of follow-up for harms.

Risk of Bias and Methodologic Quality of Included Studies

We assessed the risk of bias of the included systematic reviews and methodologic quality of clinical practice guidelines using standard instruments developed and adapted by the Center for Evidence-based Policy (Center) based on a instruments used by the other reputable organizations.[98] One experienced researcher independently rated the risk of bias of included studies. A second experienced researcher reviewed each assessment. Disagreement was managed by discussion.

Systematic Reviews

If a meta-analysis or network meta-analysis was conducted, the risk of bias of the analyses was considered in the overall rating for the systematic review. In brief, low-risk-of-bias systematic reviews include a clearly focused question, a literature search sufficiently rigorous to identify all relevant studies, criteria used to assess study quality and select studies for inclusion (e.g., RCTs), and assessment of similarities between studies to determine whether combining them is appropriate for evidence synthesis. Moderate-risk-of-bias systematic reviews have incomplete information about methods that might mask important limitations or a meaningful conflict of interest. High-risk-of-bias systematic reviews have clear flaws that could introduce significant bias.

Randomized Controlled Trials

Low-risk-of-bias RCTs include a clear description of the population, setting, intervention, and comparison groups; a random and concealed allocation of patients to study groups; low dropout rates; and intention-to-treat analyses. Low-risk-of-bias RCTs also have low potential for bias from conflicts of interest and funding source(s). Moderate-risk-of-bias RCTs have incomplete information about methods that might mask important limitations or a meaningful conflict of interest. High-risk-of-bias RCTs have clear flaws that could introduce significant bias.

Cohort Studies

Low-risk-of-bias cohort studies include a sample that is representative of the source population, have low loss to follow-up, and measure and consider relevant confounding factors. Low-risk-of-bias cohort studies also list their funding source(s) and have a low potential of bias from conflicts of interest. Moderate-risk-of-bias cohort studies might not have measured all relevant confounding factors or adjusted for them in statistical analyses, have loss to follow-up that could bias findings, consist of a sample that is not representative of the source population, or have potential conflicts of interest that are not addressed. High-risk-of-bias cohort studies have a clear, high risk of bias that would affect findings.

Clinical Practice Guidelines

We assessed the methodological quality of the guidelines using an instrument adapted from the Appraisal of Guidelines Research and Evaluation (AGREE) Collaboration.[99-101] Each rater assigned the study a rating of good, fair, or poor based on its adherence to recommended methods and potential for biases. A good-quality guideline fulfills all or most of the criteria outlined in the instrument. A fair-quality guideline fulfills some of the criteria, and its unfulfilled criteria are not likely to alter the recommendations. A poor-quality guideline met few or none of the criteria.

APPENDIX D. ADDITIONAL EVIDENCE TABLES

Table D1. Characteristics of Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR	REVIEW POPULATION	LAST SEARCH DATE # OF STUDIES SAMPLE SIZE	ANALYSIS TYPE	INCLUSION/EXCLUSION CRITERIA	BARIATRIC PROCEDURE TYPES	CONTROL GROUP DESCRIPTION	REPORTED OUTCOMES
Ablett, 2019	Adults with BMI ≥ 35	NR 3 RCTs, 6 OS N (RCTS) = 365 N (OS) = 283,040	MA	Inclusion RCTs, non-randomized controlled trials, and observational studies in adults (≥ 18 years), with mean pre-surgery group BMI ≥ 30 kg/m^2 Studies had a minimum follow-up ≥ 1 year Exclusion NR	SG RYGB AGB	Adults with obesity who did not undergo bariatric surgery	Weight change Harms
Arterburn, 2020	Adults with BMI ≥ 35	January 2020 12 RCTs N = 874	--	Inclusion Our search was limited to English-language articles Priority was given to evidence obtained from systematic literature reviews, meta-analyses, and RCTs when possible Exclusion NR	SG RYGB BPD/DS AGB	Medical therapy for obesity	Weight change Harms Chronic condition resolution
Cresci, 2020	Patients with BMI ≥ 35 and T2DM	December 2018 24 RCTs N = 1,351	NMA	Inclusion RCTs comparing different MS techniques versus MT, or comparing two different surgical procedures, with a duration ≥ 24 weeks Exclusion Animal studies were excluded	SG RYGB OAGB BPD/DS AGB	Medical therapy	Weight change QoL Harms Chronic condition resolution
Cui, 2021	Patients with BMI ≥ 35 and T2DM	February 2021 7 RCTs	MA	Inclusion Studies were eligible if they were RCTs (≥ 1 year of follow-up); included individuals with T2D; investigated currently used laparoscopic or open RYGB;	RYGB	Medical therapy for T2DM	Chronic condition resolution

AUTHOR, YEAR	REVIEW POPULATION	LAST SEARCH DATE # OF STUDIES SAMPLE SIZE	ANALYSIS TYPE	INCLUSION/EXCLUSION CRITERIA	BARIATRIC PROCEDURE TYPES	CONTROL GROUP DESCRIPTION	REPORTED OUTCOMES
		N = 447		investigated a comparator medical treatment for T2D; and reported remission of T2D or achievement of ADA's composite triple treatment goal Exclusion The major criteria to exclude studies were use of duplicate data sets, not having raw data available, or being published in a language other than English			
Hussain, 2021	Patients with BMI ≥ 35 and T2DM	March 2020 5 OS N = 49,211	MA	Inclusion Cohort studies with the following elements: (a) obese T2DM patients (BMI ≥ 35 kg/m^2) who underwent bariatric surgery, (b) defined the presence of T2DM based on HbA1c or FSG, (c) defined the outcome assessment criteria (diabetes macrovascular complications), and (d) provided estimates of the association between treatment and outcomes in the form of HR or RR, else the article should have sufficient information to compute HR or RR values Exclusion Reviews, population not of interest, outcome not of interest	RYGB BPD/DS AGB	Usual care (medical nutrition therapy, lifestyle changes, and medications)	All-cause mortality Chronic condition resolution
Khorgami, 2019	Patients with BMI ≥ 35 and T2DM	April 2018 7 RCTs N = 463	MA	Inclusion Studies were included if they (1) were prospective RCTs, (2) included patients diagnosed with T2D, (3) compared remission rates of T2D with medical treatment versus bariatric surgery, and (4) had at least 2 years of follow-up Exclusion NR	SG RYGB BPD/DS AGB	Medical treatment for obesity and T2DM	Chronic condition resolution
Malczak, 2021	Adults with BMI ≥ 35	April 2020	NMA	Inclusion	SG RYGB	Lifestyle interventions	QoL

AUTHOR, YEAR	REVIEW POPULATION	LAST SEARCH DATE # OF STUDIES SAMPLE SIZE	ANALYSIS TYPE	INCLUSION/EXCLUSION CRITERIA	BARIATRIC PROCEDURE TYPES	CONTROL GROUP DESCRIPTION	REPORTED OUTCOMES
		17 RCTs, 30 OS N = 26,629		Studies were eligible for inclusion if they were RCTs or non-randomized studies with a control group, such as cohort studies (prospective or retrospective) The included study had to include at least two arms (one of which is bariatric surgery) and the follow-up period was 1 year, 2 years, 3 years, or 5 years Studies must have reported on health-related QoL using any validated tools <u>Exclusion</u> Letters, editorials, case reports, case-series, and review papers were excluded Published abstracts were not included due to limited information available for analysis and the RoB assessment	OAGB BPD/DS		
Park, 2019	Adults with BMI ≥ 35	February 2018 45 RCTs N = 4,089	MA, NMA	<u>Inclusion</u> (a) Patients: underwent bariatric surgery, (b) intervention: bariatric surgery, (c) comparator: another method of bariatric surgery or standard-of-care without bariatric surgery, and (d) outcome: % EWL from 6 months to 5 years, and T2DM remission rate from 1 to 5 years <u>Exclusion</u> (a) Non-original studies, (b) non-RCTs, (c) non-human studies, (d) unpublished studies, and (e) non-English publications	SG RYGB BPD/DS AGB VBG GP MGB	Standard-of-care without bariatric surgery	Weight change Harms Chronic condition resolution
Pontiroli, 2020	Adults with BMI ≥ 35	October 2019 9 OS N = 607,643	MA	<u>Inclusion</u> Eligible CCS were those comparing bariatric surgery versus no-surgery in persons with morbid obesity, irrespective of publication status or language	SG RYGB BPD/DS	Medical treatment for obesity	All-cause mortality

AUTHOR, YEAR	REVIEW POPULATION	LAST SEARCH DATE # OF STUDIES SAMPLE SIZE	ANALYSIS TYPE	INCLUSION/EXCLUSION CRITERIA	BARIATRIC PROCEDURE TYPES	CONTROL GROUP DESCRIPTION	REPORTED OUTCOMES
				<u>Exclusion</u> Reviews and meta-analyses; studies without measures of dispersion of data were excluded at a second step, as well as studies without comparisons between surgery and control patients			
Robertson, 2020	Adults with BMI ≥ 35	July 2020 58 OS N = 3,650,961	MA	<u>Inclusion</u> English-only studies of at least 1000 patients reporting short-term mortality after bariatric surgery; RCTs with smaller patient numbers were included in the data collection for assessment of pooled mortality rates in this subset of specialized study types but were not included in the main analysis <u>Exclusion</u> Studies that did not report perioperative mortality and studies based on overlapping cohorts of patients were excluded	SG RYGB OAGB BPD/DS AGB	NR - analyses conducted for surgical patients only	Harms
Syn, 2021	Adults with BMI ≥ 35	February 2021 17 OS N = 174,772	MA	<u>Inclusion</u> Low-RoB randomized trials, prospective controlled studies, and matched cohort studies comparing all-cause mortality after metabolic–bariatric surgery versus non-surgical management of obesity published from inception to February 3, 2021 <u>Exclusion</u> Excluded from the meta-analysis were studies that exclusively enrolled patients with specific comorbidities other than T2DM (e.g., end-stage renal failure and type 1 diabetes) or adolescents, non-comparative studies, and case reports	SG RYGB OAGB BPD/DS AGB	Non-surgical management of obesity	All-cause mortality
Wang, 2021	Adults with BMI ≥ 35	May 2021 19 RCTs	MA	<u>Inclusion</u> RCTs (≥ 12-month follow-up); included individuals with a BMI ≥ 28; investigated all currently available	SG RYGB	Nonsurgical treatment for obesity (i.e., diet,	Weight change Harms Chronic

AUTHOR, YEAR	REVIEW POPULATION	LAST SEARCH DATE # OF STUDIES SAMPLE SIZE	ANALYSIS TYPE	INCLUSION/EXCLUSION CRITERIA	BARIATRIC PROCEDURE TYPES	CONTROL GROUP DESCRIPTION	REPORTED OUTCOMES
		N = 663		bariatric surgeries (including LAGB, RYGB, SG, BPD/DS, VBG, DJBL); investigated as comparator nonsurgical treatment for obesity (diet, weight reducing drugs, behavioral therapy); and reported changes in blood pressure or changes in the use of antihypertension medications Exclusion NR	BPD/DS AGB	weight-reducing drugs, behavioral therapy)	condition resolution
Yan, 2019	Adults with BMI ≥ 35 and T2DM	January 2019 4 RCTs, 6 OS N = 50,150	MA	Inclusion (1) RCT or cohort studies; (2) comparison of bariatric surgery including RYGB, AGB, SG, VBG, and BPD/DS to conventional medical therapy; (3) reported at least one of the main outcomes of interest (macrovascular events, mortality, or metabolic outcomes); (4) patient follow-up beyond 5 years; (5) studies enrolling adults with baseline BMI ≥ 35. Exclusion (1) trials without conventional medical therapy as control; (2) severely obese patients without T2DM; (3) follow up less than 5 years; (4) patients with BMI less than 35; (5) did not target our interest outcomes; (6) publication forms other than peer reviewed articles	SG RYGB BPD/DS ESG AGB	Conventional medical therapy for obesity (e.g., intensive lifestyle intervention and pharmacotherapy)	Weight change Chronic condition resolution

Abbreviations. ADA: American Diabetes Association; AGB: adjustable gastric banding; BMI: body mass index; BPD/DS: biliopancreatic diversion with duodenal switch; ESG: Endoscopic sleeve gastroplasty; EWL: excess weight loss; GP: gastric plication; HbA1c: glycated hemoglobin; HR: hazard ratio; kg/m^2: kilograms per meters squared; MA: meta-analyses; MS: multiple sclerosis; MT: medical therapy; NMA: network meta-analysis; NR: not reported; OAGB: one anastomosis gastric bypass; OS: observational studies; QoL: quality of life; RCT: randomized controlled trial; RoB: risk of bias; RR: relative risk; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; T2DM: type 2 diabetes mellitus; VBG: vertical banded gastroplasty.

Table D2. Characteristics of Primary Studies in Included Reviews of Adults with BMI ≥ 35

AUTHOR, YEAR	REVIEW POPULATION	PUBLICATION DATE (RANGE)	FOLLOW-UP (RANGE)	SAMPLE SIZE (RANGE)	MEAN AGE (RANGE)	MEAN BMI (RANGE)	% FEMALE (RANGE)	% NON-WHITE (RANGE)	COMORBIDITIES
Ablett, 2019	Adults with BMI ≥ 35	RCTs: 2010 to 2015 OS: 2012 to 2018	RCTs: 2 years max f/u OS: 2.2 to 8.9 years	RCTs: 69 to 150 OS: NR	RCTs: 42.8 to 50.0 years OS: 31.8 to 45.0 years	RCTs: 35.3 to 46.7 OS: 40.8 to 49.0	RCTs: 47.1% to 82.6% OS: 63.7% to 85.3%	RCTs: 7.5% to 32.6% OS: NR	T2DM, HTN, CAD, metabolic syndrome, dyslipidemia
Arterburn, 2020	Adults with BMI ≥ 35	2008 to 2020	1 to 5 years	38 to 150	NR	NR	NR	NR	
Cresci, 2020	Patients with BMI ≥ 35 and T2DM	2008 to 2018	26 to 260 weeks	3 to 120	Min and max 18 to 75 years	29.0 to 48.5	NR	NR	NR
Cui, 2021	Patients with BMI ≥ 35 and T2DM	2012 to 2020	1 to 5 years	32 to 120	RYGB: 43.9 to 52.5 years MT: 43.5 to 54.6 years	RYGB: 32.6 to 44.9 MT: 32.6 to 45.6	RYGB: 45% to 80% MT: 45% to 83%	NR	T2DM
Hussain, 2021	Patients with BMI ≥ 35 and T2DM	2014 to 2018	1.8 to 18.1 years	158 to 15,951	45.8 to 49.5 years	42.0 to 49.9	59% to 78.2%	NR	T2DM
Khorgami, 2019	Patients with BMI ≥ 35 and T2DM	2008 to 2018	2 to 5 years	38 to 120	NR	25 to > 45	NR	NR	T2DM
Malczak, 2021	Adults with BMI ≥ 35	2004 to 2020	NR	NR	NR	33.6 to 55.0	NR	NR	T2DM, HTN, OSA
Park, 2019	Adults with BMI ≥ 35	2005 to 2018	NR	14 to 240	NR	Limited to BMI ≥ 35: 31 studies Includes BMI < 35: 14 studies	NR	NR	NR
Pontiroli, 2020	Adults with BMI ≥ 35	2007 to 2019	4 to 14 years		38 to 46 years	NR	54% to 80%	NR	CAD, T2DM, cancer

AUTHOR, YEAR	REVIEW POPULATION	PUBLICATION DATE (RANGE)	FOLLOW-UP (RANGE)	SAMPLE SIZE (RANGE)	MEAN AGE (RANGE)	MEAN BMI (RANGE)	% FEMALE (RANGE)	% NON-WHITE (RANGE)	COMORBIDITIES
Robertson, 2020	Adults with BMI ≥ 35	2009 to 2020	In-hospital to 90 days post-surgery	1008 to 1,903,273	33.1 to 55.4 years	35.9 to 51.7	NR	NR	NR
Syn, 2021	Adults with BMI ≥ 35	2007 to 2020	2.6 to 24.0 years	535 to 33,540	Surgery: 36 to 62 years Control: 36 to 61 years	Surgery: 37.4 to 48.6 Control: 36.6 to 48.1	Surgery: 26% to 82% Control: 26% to 82%	Surgery: 3.7% to 100% Control: 1.9% to 100%	T2DM, HTN, dyslipidemia, CAD, heart failure, peripheral neuropathy, COPD
Wang, 2021	Adults with BMI ≥ 35	2006 to 2021	Mean, 2.8 years Range, 1 to 10 years	20 to 150	16.5 to 56 years	29.0 to 49.2	31% to 93%	NR	T2DM, metabolic syndrome
Yan, 2019	Adults with BMI ≥ 35 and T2DM	2011 to 2018	5 to 15 years	50 to 20,235	Most studies, ≥ 45 years	≥ 34 to ≤ 45	All studies included both men and women (proportions NR)	NR	T2DM

Abbreviations. BMI: body mass index; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; f/u: follow-up; HTN: hypertension; max.: maximum; min.: minimum; MT: medical therapy; NR: not reported; OS: observational studies; OSA: obstructive sleep apnea; RCT: randomized controlled trial; RYGB: Roux-en-Y gastric bypass; T2DM: type 2 diabetes mellitus.

Table D3. Outcomes in Adults with BMI ≥ 35: All-cause Mortality, Weight Change, Quality of Life, and Harms

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
Ablett, 2019 3 RCTs, 6 OS N (RCTS) = 365 N (OS) = 283,040 Moderate	Adults with BMI ≥ 35	NR	MEAN WEIGHT LOSS RCTs only IGn: 159 CGn: 103 MD, -22.2 kg (95% CI, -31.6 to -12.8; *P*< .0001)	NR	FRACTURE RATE RCTs IG: 8 of 226 CG: 5 of 139 RR, 0.82 (95% CI, 0.29 to 2.35; *P* = .72) Observational studies IG: 1,872 of 59,930 CG: 5,408 of 23,110 4 out of the 6 observational studies reported a statistically significant association between bariatric surgery and an increased likelihood of fracture compared to nonsurgical weight loss interventions (HR range, 1.21 to 2.3)
Arterburn, 2020 12 RCTs N = 874 High	Adults with BMI ≥ 35	NR	NR	NR	REOPERATIONS RCT data (5-year results, RYGB vs. SG) SLEEVEPASS trial SG: 8.3% RYGB: 15.1% *P*= .10 SM-BOSS trial SG: 15.8%

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
					RYGB: 22.1% *P*= .33 Cohort study data Overall reoperation rate range, 5% to 22% Rates lower with SG compared with RYGB KP cohort (N = 35,273): HR, 0.78 (95% CI, 0.74 to 0.84) Optum cohort (N =13,027): HR, 0.80 (95% CI, 0.72 to 0.89) National Patient-Centered Clinical Research Network cohort (N = 33,560): HR, 0.72 (95% CI, 0.65 to 0.79) 10- year reoperation rates Among 7 studies of RYGB, rates of reoperation ranged from 8% to 64% (median 29%) In 2 studies of SG, rates of reoperation were 32% and 36%
Cresci, 2020 24 RCTs	Adults with BMI ≥ 35 and T2DM	NR	% WEIGHT LOSS IGn: 355 CGn: 267	SF-36 3 RCTs: superior scores among participants with bariatric	SAE IG: 72 of 386 CG: 44 of 337

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
N = 1,351 Moderate			MD, -16.83 (95% CI, -18.03 to -15.62; *P*< .001)* CHANGE IN MEAN BMI Overall (Surg vs. MT) IGn: 386 CGn: 337 MD, -5.74 (95% CI, -7.05 to -4.43; *P*< .001)* Subgroup: minimum BMI for enrollment BMI < 30 IGn: 156 CGn: 146 MD, -3.80 (95% CI, -5.81 to -1.80; *P*= .003)* BMI 30 to 34.9 IGn: 190 CGn: 171 MD, -5.86 (95% CI, -6.78 to -4.95; *P*< .0001)* BMI ≥ 35 IGn: 40 CGn: 20 MD, -11.30 (95% CI, -14.01 to -8.59; *P*< .0001)* Subgroup: procedure type AGB IGn: 76	procedures (i.e., AGB, BPD/DS, RYGB) vs. controls at 5 years 1 RCT: improvements noted in both groups; no significant between-group difference in scores at 3 years EQ5D 1 RCT: improvements noted in both groups (RYGB vs. medical controls); no significant between-group difference in scores at 1 year IWQoL 1 RCT: superior scores among participants with RYGB vs. controls at 3 years PAID 1 RCT: improvements noted in both groups (RYGB vs. medical controls); no significant between-group difference in scores at 3 years	HR, 1.44 (95% CI, 0.66 to 3.16; *P* = .36) DEATH IG: 0 of 386 CG: 3 of 337 HR, 0.21 (95% CI, 0.03 to 1.32; *P* =.10) REVISIONAL SURGERY IG: 4 of 386 CG: 0 of 337 HR, 3.72 (95% CI, 0.43 to 32.49; *P*= .23) SEVERE HYPOGLYCEMIA IG: 4 of 386 CG: 4 of 337 HR, 0.69 (95% CI, 0.19 to 2.52; *P* = .58)

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
			CGn: 76 MD, -4.22 (95% CI, -7.25 to -1.19; *P*= .006)* RYGB IGn: 215 CGn: 256 MD, -6.22 (95% CI, -7.73 to -4.71; *P*< .001)* BPD IGn: 20 CGn: 20 MD, -11.80 (95% CI, -14.89 to -8.71; *P*< .0001)* SG IGn: 50 CGn: 50 MD, -5.70 (95% CI, -7.06 to -4.34; *P*< .0001)* Subgroup: trial duration > 104 weeks IGn: 285 CGn: 195 MD, -5.62 (95% CI, -7.66 to -3.58; *P*< .0001)* ≤ 104 weeks IGn: 101 CGn: 142		

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
			MD, -5.92 (95% CI, -7.09 to -4.75; *P*= .15)		
Hussain, 2021 5 OS N = 49,211 High	Adults with BMI ≥ 35 and T2DM	RISK OF ALL-CAUSE MORTALITY (Surg. vs. MT) 2 studies (sample sizes by group NR) RR, 0.39 (95% CI, 0.30 to 0.50; *P* < .0001)	NR	NR	
Malczak, 2021 17 RCTs, 30 OS N = 26,629 High	Adults with BMI ≥ 35	NR	NR	OVERALL QOL 3-year follow-up (NMA: 4 RCTs, 6 observational studies) AGB: SMD, 0.78 (95% CI, 0.40 to 1.17) BPD/DS: SMD, 1.16 (95% CI, 0.45 to 1.87) RYGB: SMD, 0.96 (95% CI, 0.65 to 1.29) RYGB (banded): 0.48 (95% CI, -0.50 to 1.46) SG: SMD, 0.9 (95% CI, 0.58 to 1.23) 5 years follow-up (NMA: 4 RCTs, 3 observational studies) BPD/DS: SMD, 1.43 (95% CI, 1.00 to 1.87) OAGB: SMD, 1.01 (95% CI, 0.63 to 1.4) RYGB: SMD, 1.27 (95% CI, 0.94	NR

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
				to 1.61) SG: SMD, 0.92 (95% CI, 0.58 to 1.26) GIQLI Scale (Score range 0 to 144) 3 year follow-up (NMA: 4 RCTs, 6 observational studies) AGB: MD, 17.38 (95% CI, 8.87 to 25.92) BPD/DS: MD, 25.76 (95% CI, 9.88 to 41.58) RYGB: MD, 21.4 (95% CI, 14.37 to 28.51) RYGB (banded): MD, 10.63 (95% CI, -11.08 to 32.28) SG: MD, 20.05 (95% CI, 12.89 to 27.29) 5-year follow-up (NMA: 4 RCTs, 3 observational studies) BPD-DS: MD, 17.49 (95% CI, 12.85 to 24.15) OAGB: MD, 13.01 (8.11 to 17.98) RYGB: MD, 16.36 (95% CI, 12.08 to 20.69) SG: MD, 11.83 (95% CI, 7.53 to 16.18)	
Park, 2019 45 RCTs	Adults with BMI ≥ 35	NR	% EXCESS WEIGHT LOSS (surg vs. control)* 3 years follow-up	NR	MORTALITY RATE AGB: no deaths BPD-DS: no deaths

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
N = 4,089 Low			AGB: MD, 19.0% (95% CI, 0.13 to 37.9) RYGB: MD, 45.0% (95% CI, 21.8 to 68.2) SG: MD, 39.2% (95% CI, 15.2 to 63.3) VBG: MD, 38.1% (95% CI, -27.4 to 103.6) 2 years follow-up AGB: MD, 52.8% (95% CI, 35.3 to 70.4) BPD: MD, 70.1% (95% CI, 50.9 to 90.8) GP: MD, 56.9% (95% CI, 27.0 to 86.8) MGP: MD, 75.0% (95% CI, 42.9 to 107.2) RYGB: MD, 69.8% (95% CI, 52.2 to 87.4) SG: MD, 73.9% (95% CI, 51.3 to 96.5) VBG: MD, 57.0% (95% CI, 31.8 to 82.2) 1 year follow-up AGB: MD, 26.9% (95% CI, 14.6 to 39.1) BPD: MD, 69.5% (95% CI, 42.5 to 96.4) BPD-DS: MD, 70.7% (95% CI, 45.4 to 96.0) GP: MD, 52.7% (95% CI, 27.1 to		GP: 1 death (pulmonary embolism; mortality rate, 1.1%) RYGB: 2 deaths (lymphoma and drug abuse; mortality rate, 0.1% [95% CI, 0.0 to 0.7%]) SG: no deaths VBG: 2 deaths (sepsis and pneumonia; mortality rate 2.0%) SURGICAL ADVERSE EVENTS (proportion) Hernia AGB: NR BPD-DS: 1.8% RYGB: 5.1% (95% CI, 4.0 to 6.5%; $P < .01$) SG: 0.6% Obstruction/stricture AGB: 0.8% BPD-DS: NR RYGB: 4.0% (95% CI, 3.0 to 5.3%; $P < .01$) SG: 1.2% Gastrointestinal bleeding AGB: NR BPD-DS: 3.5% RYGB: 2.0% (95% CI, 1.4 to 3.0%; $P < .05$) SG: 0.8% Leakage/perforation

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
			78.4) MGB: MD, 65.2% (95% CI, 40.2 to 90.2) RYGB: MD, 60.1% (95% CI, 36.7 to 83.5) SG: MD, 60.2% (95% CI, 36.2 to 84.2) VBG: MD, 44.7% (95% CI, 28.3 to 61.0)		AGB: 0.8% BPD-DS: 3.5% RYGB: 0.9% SG: 0.7% Wound infection AGB: 0.3% BPD-DS: 1.8% RYGB: 1.1% SG: 1.1% Ulcer AGB: 0.3% BPD-DS: NR RYGB: 1.5% (95% CI, 1.0 to 2.4%; *P* < .01) SG: 0.2% Dumping syndrome AGB: NR BPD-DS: NR RYGB: 0.7% SG: 0.2% Hemoperitoneum AGB: NR BPD-DS: NR RYGB: 0.1% SG: NR AGB-only Pouch dilatation/slippage: 10.9%

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
					Band erosion: 0.8% Band slippage: 0.8%
Pontiroli, 2020 9 OS N = 607,643 Moderate	Adults with BMI ≥ 35	GLOBAL MORTALITY (8.7 years median follow-up; Surg vs. MT) Overall IG: 2,274 of 72,267 CG: 79,134 of 535,376 OR, 0.29 (95% CI, 0.17 to 0.49; *P* = .001) Subgroup: age Below Median Age IG: 721 of 35,627 CG: 6,695 of 266,160 OR, 0.78 (95% CI, 0.57 to 1.06; *P* = .110) Above Median Age IG: 1,553 of 35,674 CG: 70,165 of 267,097 OR, 0.23 (95% CI, 0.12 to 0.44; *P* = .001)	NR	NR	NR
Robertson, 2020 58 OS N = 3,650,961 Moderate	Adults with BMI ≥ 35	NR	NR	NR	PERIOPERATIVE MORTALITY RATE (%) Overall pooled estimate (any time point up to 90 days) Events: 4,707 of 3,650,961 Rate: 0.08 (95% CI, 0.06 to 0.10) Subgroup: reporting type

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
					30-day mortality: 0.07 (95% CI, 0.05 to 0.08) 90-day mortality: 0.11 (95% CI, 0.06 to 0.17) In-hospital mortality: 0.12 (95% CI, 0.05 to 0.20) Subgroup: procedure type SG: 0.05 (95% CI, 0.02 to 0.07) RYGB: 0.09 (95% CI, 0.06 to 0.13) OAGB: 0.09 (95% CI, 0.03 to 0.19) BPD-DS: 0.41 (95% CI, 0.25 to 0.60) AGB: 0.03 (95% CI, 0 to 0.09) Subgroup: study type Bariatric surgery registry: 0.07 (95% CI, 0.05 to 0.10) Administrative databases: 0.10 (95% CI, 0.06 to 0.14) Large series: 0.08 (95% CI, 0.05 to 0.11)
Syn, 2021 17 OS N = 174,772 Low	Adults with BMI ≥ 35	CUMULATIVE ALL-CAUSE MORTALITY Overall (Surg. vs. MT) IG: 1,813 deaths of 65,785 patients (over 496,771 patient-years) CG: 5,899 of 108,987 (over 659,605 patient-years)	NR	NR	NR

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		HR, 0.508 (95% CI, 0.481 to 0.537; *P*< .0001) Subgroup: diabetes status Patients with T2DM IG: 456 of 16,190 (over 70,984 PYs) CG: 2939 of 38,853 (over 170,933 PYs) HR, 0.409 (95% CI, 0.370 to 0.453; *P*< .0001) Patients without T2DM IG: 165 of 3256 (over 25,054 PYs) CG: 510 of 5740 (over 44,756 PYs) HR, 0.704 (95% CI, 0.588 to 0.843; *P*< .0001) Subgroup: procedure type RYBG patients vs. matched controls IG: 546 of 23,450 (over 216,413 PYs) CG: 1,070 of 26,554 (over 185,593 PYs) HR, 0.430 (95% CI, 0.387 to 0.478; *P*< .0001) SG patients vs. matched controls IG: 59 of 7,373 (over 38,531 PYs) CG: 209 of 14,097 (over 58,559			

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		PYs) HR, 0.475 (95% CI, 0.354 to 0.639; *P*< .0001) AGB patients vs. matched controls IG: 96 of 4,815 (over 34,369 PYs) CG: 454 of 12,407 (over 82,038 PYs) HR, 0.500 (95% CI, 0.401 to 0.624; *P*< .0001) RELATIVE HAZARD RATE REDUCTION OF DEATH (with bariatric procedures) Overall: 49.2% (95% CI, 46.3 to 51.9; *P*< .0001) Patients with T2DM: -59.1% Patients without T2DM: -29.6% NUMBER NEEDED TO TREAT (to prevent 1 additional death) 10-year follow-up Overall: 24.4 (95% CI, 23.1 to 26.0) Patients with T2DM: 8.4 (95% CI, 7.8 to 9.1) Patients without T2DM: 29.8 (95% CI, 21.2 to 56.8) 20-year follow-up Overall: 10.8 (95% CI, 10.2 to 11.5)			

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		Patients with T2DM: 5.3 (95% CI, 4.9 to 5.8) Patients without T2DM: 19.0 (95% CI, 13.4 to 36.3) MEDIAN LIFE EXPECTANCY (gain with bariatric procedures) Overall: +6.1 years (95% CI, 5.2 to 6.9) Patients with T2DM: +9.3 years (95% CI, 7.1 to 11.8) Patients without T2DM: +5.1 years (95% CI, 2.0 to 9.3)			
Wang, 2021 19 RCTs N = 663 Low	Adults with BMI ≥ 35	NR	CHANGE IN BODY WEIGHT (kg) [surg vs. nonsurg control] Overall: WMD, -18.47 (95% CI, -22.99 to -13.93; *P*< .001) Subgroup: procedure type AGB: WMD, -14.83 (95% CI, -22.81 to -6.84; *P*< .05)* SG: WMD, -16.32 (95% CI, -22.30 to -10.34; *P*< .05)* DJBL: WMD, -2.80 (95% CI, -10.93 to 5.33; *P*= NS) RYGB: WMD, -21.36 (95% CI, -26.61 to -16.12; *P*< .05)* BPD: WMD, -33.58 (95% CI, -38.69 to -28.47; *P*< .05)* CHANGE IN BMI Overall: WMD, -4.79 (95% CI, -	NR	ADVERSE EVENTS IG: 603 events (0.28 per person per year) CG: 393 events (0.23 per person per year) DEATHS IG: 2 deaths (1 after CABG surgery; 1 cause not reported) CG: 2 deaths (both fatal MI)

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	ALL-CAUSE MORTALITY	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
			7.92 to -1.66; *P*< .0001) Subgroup: procedure type AGB: WMD, -0.44 (95% CI, -5.02 to 4.13; *P*= NS) SG: WMD, -8.00 (95% CI, -10.06 to -5.94; *P*= NR) DJBL: WMD, -0.90 (95% CI, -3.20 to 1.40; *P*= NR) RYGB: WMD, 8.12 (95% CI, -11.85 to -4.40; *P*< .0001) BPD: WMD, -11.95 (95% CI, -13.55 to -10.35; *P*= .81)		
Yan, 2019 4 RCTs, 6 OS N = 50,150 Moderate	Adults with BMI ≥ 35 and T2DM	NR	MEAN BMI* Overall (5 studies): WMD, -8.49 (95% CI, -9.25 to -2.58) Subgroup: procedure type RYGB (3 studies): WMD, -5.92 (95% CI, -9.25 to -2.58) BPD (2 studies): WMD, -11.90 (95% CI, -29.11 to 5.31)	NR	NR

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BPD: biliopancreatic diversion; BPD/DS: biliopancreatic diversion with duodenal switch; CG: control group; CG n: control group sample size; CI: confidence interval; EQ5D: EuroQol-5 Dimensions; GIQLI: Gastrointestinal Quality of Life Index; GP: gastric plication; HR: hazard ratio; IG: intervention group; IG n: intervention group sample size; IWQoL: Impact of Weight on Quality of Life scale; kg: kilogram; MD: mean difference; MGB: mini gastric bypass; MT: medical therapy; NMA: network meta-analysis; Nonsurg: nonsurgical; NR: not reported; OAGB: one anastomosis gastric bypass; OR: odds ratio; OS: observational studies; PAID: Problem Areas in Diabetes scale; PY: per year; QoL: quality of life; RCT: randomized controlled trial; ROB: risk of bias; RR: relative risk or risk ratio; RYGB: Roux-en-Y gastric bypass; SAE: serious adverse events; SF-36: short form 36; SG: sleeve gastrectomy; SLEEVEPASS: Sleeve vs. Bypass Trial; SM-BOSS: Swiss Multicenter Bypass or Sleeve Study; SMD: standardized mean difference; Surg.: bariatric surgery; T2DM: type 2 diabetes mellitus; VBG: vertical banded gastroplasty; WMD: weighted mean difference.

Table D4. Outcomes in Adults with BMI ≥ 35: Improvement or Resolution of Chronic Conditions

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
Arterburn, 2020 12 RCTs N = 874 High	Adults with BMI ≥ 35	NR	NR	NR
Cresci, 2020 24 RCTs N = 1,351 Moderate	Patients with BMI ≥ 35 and T2DM	T2DM REMISSION IG: 123 of 356 CG: 6 of 307 OR, 19.26 (95% CI, 5.68 to 65.31; *P*= .001)* (Definition: A1c < 6.5% without medication)	HTN RESOLUTION 2 studies: Fewer participants using anti-HTN medications in surgical groups (change range, -28 to -48 percentage points) vs. comparator groups (change range, 0 to +10 percentage points) at end of study SYSTOLIC BP CHANGE IGn: 355 CGn: 267 MD, -2.62 (95% CI, -4.46 to -0.79; *P*= .005) DIASTOLIC BP CHANGE IGn: 355 CGn: 267 MD, 0.91 (95% CI, -1.54 to 3.36; *P*= .46)	NR
Cui, 2021 7 RCTs N = 447 Moderate	Patients with BMI ≥ 35 and T2DM	T2DM REMISSION (RYGB vs. control) Remission at 1 year (4 RCTs) IG: 42 of 149 CG: 1 of 150 RR, 18.01 (95% CI, 4.53 to 71.70; *P*< .0001)	NR	NR

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
		Remission at 2 years (4 RCTs) IG: 85 of 155 CG: 25 of 152 RR, 12.70 (95% CI, 0.45 to 358.63; *P*= .14) Remission at 3 years (3 RCTs) IG: 47 of 134 CG: 0 of 133 RR, 29.58 (95% CI, 5.92 to 147.82; *P*< .0001) Remission at 5 years (3 RCTs) IG: 33 of 154 CG: 0 of 153 RR, 16.92 (95% CI, 4.15 to 69.00; *P*< .0001)		
Hussain, 2021 5 OS N = 49,211 High	Patients with BMI ≥ 35 and T2DM	NR	NR	MACROVASCULAR COMPLICATIONS IGn: 14,434 CGn: 34,777 RR, 0.50 (95% CI, 0.35 to 0.73; *P*= .0003) Adjusted RR, 0.54 (95% CI, 0.37 to 0.79; *P*= .002)
Khorgami, 2019 7 RCTs N = 463 Moderate	Patients with BMI ≥ 35 and T2DM	T2DM REMISSION Remission at 5 years Overall IG: 62 of 225 CG: 7 of 156 RR, 6.0 (95% CI, 2.7 to 13.0; *P*< .0001)	NR	NR

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
		Remission at 2 years Overall IG: 138 of 263 CG: 7 of 200 RR, 10.0 (95% CI, 5.5 to 17.9; *P* < .0001) Subgroup: procedure type RYGB IG: 77 of 146 CG: 5 of 144 RR, 15.2 (95% CI, 6.3 to 36.5; *P* < .0001) AGB IG: 40 of 77 CG: 7 of 79 RR, 5.8 (95% CI, 2.8 to 12.1; *P* < .0001)		
Park, 2019 45 RCTs N = 4,089 Low	Patients with BMI ≥ 35	T2DM REMISSION Late Remission (3 to 5 years after surgery) BPD: RR, 31.8 (95% CI, 5.0 to 201.8) BPD-DS: RR, 7.5 (95% CI, 1.9 to 29.5) RYGB: RR, 7.5 (95% CI, 2.0 to 28.5) SG: RR, 6.7 (95% CI, 1.8 to 25.6) Early Remission (1 to 2 years after surgery) AGB: RR, 7.6 (95% CI, 3.4 to 16.8) BPD: RR, 14.3 (95% CI, 5.7 to 36.2) BPD-DS: RR, 11.0 (95% CI, 4.2 to 28.9) GP: RR, 3.6 (95% CI, 1.2 to 11.0) MGB: RR, 12.2 (95% CI, 4.7 to 31.5) RYGB: RR, 11.2 (95% CI, 4.7 to 26.4) SG: RR, 9.1 (95% CI, 3.7 to 22.5)	NR	NR

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
Wang, 2021 19 RCTs N = 663 Low	Patients with BMI ≥ 35	CHANGE IN USE OF METFORMIN (from baseline)* IG: RR, 0.464 (95% CI, 0.247 to 0.872; *P*= .017) CG: RR, 0.979 (95% CI, 0.808 to 1.186; *P*= .826) CHANGE IN USE OF INSULIN (from baseline)* IG: RR, 0.345 (95% CI, 0.229 to 0.520; *P*< .001) CG: RR, 0.933 (95% CI, 0.748 1.163 to 0.535; *P*< .001) CHANGE IN USE OF OTHER DIABETES MEDICATION (from baseline) IG: RR, 0.549 (95% CI, 0.420 to 0.719; *P*< .001) CG: RR, 0.891 (95% CI, 0.797 to 0.995; *P*< .001)	SYSTOLIC BP (mean change, surg vs. control) Overall: WMD, -3.94 mmHg (95% CI, -6.00 to -1.88; *P*< .001)* Subgroup: age < 45 years: WMD, −2.23 (95% CI, −5.85 to 1.40; *P*= .23) ≥ 45 years: WMD, −4.76 (95% CI, −7.27 to −2.25; *P*< .001)* Subgroup: baseline BMI < 40: WMD, −0.17 (95% CI, −6.25 to 5.91; *P* = .956) > 40: WMD, −4.43 (95% CI, −6.62 to −2.24; *P* < .001) Baseline: baseline HbA1c < 7.0%: WMD, −2.90 (95% CI, −6.59 to 0.78; *P*= .122) > 7.0%: WMD, −4.98 (95% CI, −7.81 to −2.15; *P*= .001)* Subgroup: procedure type AGB: WMD, −2.54 (95% CI, −5.69 to 0.62; *P*= .12) BPD: WMD, −5.60 (95% CI, −16.14 to 4.94; *P* = .30) RYGB: WMD, −5.75 (95% CI, −10.11 to −1.40; *P*= .01)* SG: WMD, −4.30 (95% CI, −15.06 to 6.46; *P*= .43)	NR

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
			DIASTOLIC BP (mean change, surg vs control) Overall: WMD, -2.69 mmHg (95% CI, -3.99 to -1.39; *P*< .001)* Subgroup: age < 45 years: WMD, −2.43 (95% CI, −5.66 to 0.81; *P*= .14) ≥ 45 years: WMD, −2.73 (95% CI, −4.28 to −1.17; *P*= .001)* Subgroup: baseline BMI < 40: WMD, 0.27 (95% CI, −2.98 to 3.52; *P*= .87) > 40: WMD, −3.26 (95% CI, −4.68 to −1.84; *P* < .001)* Baseline: baseline HbA1c < 7.0%: WMD, −2.15 (95% CI, −4.72 to 0.41; *P*= .10) > 7.0%: WMD, −2.99 (95% CI, −4.74 to −1.25; *P*= .001)* Subgroup: procedure type AGB: WMD, −2.12 (95% CI, −4.63 to 0.39; *P*= .09) BPD: WMD, −1.78 (95% CI, −6.72 to 3.15; *P*= .48) RYGB: WMD, −2.54 (95% CI, −4.69 to −0.38; *P*= .02)* SG: WMD, −3.90 (95% CI, −10.53 to 2.73; *P*= .25)	

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
			USE OF ANTIHYPERTENSIVES (change in % using from baseline) IG Baseline (mean %): 67.3% (95% CI, 59.2 to 75.3%) Follow-up: 37.3% (95% CI, 29.0 to 45.6%) MD, -0.91 per capita reduction (95% CI, -1.49 to -0.33; *P*= .002) CG Baseline: 70.9% (95% CI, 63.1 to 78.7%) Follow-up: 68.4% (95% CI, 60.3 to 76.5%) MD, -0.05 (95% CI, -0.39 to 0.29; *P*= .776)	
Yan, 2019 4 RCTs, 6 OS N = 50,150 Moderate	Patients with BMI ≥ 35 and T2DM	NR	SYSTOLIC BP (mean change, MBS vs. MT) Subgroup: procedure type RYGB (3 studies): WMD, 0.00 (95% CI, -0.11 to 0.11) BPD (2 studies): WMD, -2.66 (95% CI, -5.46 to 0.14) DIASTOLIC BP (mean change, MBS vs. MT) Subgroup: procedure type RYGB (3 studies): WMD, 0.90 (95% CI, 0.82 to 0.97) BPD (2 studies): WMD, -0.34 (95% CI, -1.94 to 1.27)	MACROVASCULAR COMPLICATIONS Overall IG: 503 of 14,938 CG: 2,525 of 35,125 RR, 0.43 (95% CI, 0.27 to 0.70) Adjusted HR analysis N = 8,569 (4 studies) HR, 0.52 (95% CI, 0.39 to 0.71) Subgroup: Study Design RCTs IG: 68 of 482 CG: 67 of 320 RR, 0.75 (95% CI, 0.44 to 1.26) Prospective cohort studies IG: 270 of 6,497 CG: 568 of 6,420 RR, 0.42 (95% CI, 0.15 to 1.21)

AUTHOR, YEAR # OF STUDIES SAMPLE SIZE ROB	REVIEW POPULATION	DIABETES	HYPERTENSION	CONORARY ARTERY DISEASE
				Retrospective cohort studies IG: 165 of 7,959 CG: 1,890 of 28,385 RR, 0.31 (95% CI, 0.16 to 0.62) CARDIOVASCULAR EVENTS (adjusted HR analysis) N = 8,569 (3 studies) HR, 0.52 (95% CI, 0.39 to 0.71) MYOCARDIAL INFARCTION Overall IG: 148 of 14,517 CG: 754 of 34,785 RR, 0.46 (95% CI, 0.38 to 0.55) Subgroup: Study Design RCTs IG: 38 of 482 CG: 45 of 320 RR, 0.63 (95% CI, 0.43 to 0.93) Prospective cohort studies IG: 24 of 6,154 CG: 70 of 6,160 RR, 0.35 (95% CI, 0.22 to 0.55) Retrospective cohort studies IG: 86 of 7881 CG: 639 of 28,305 RR, 0.45 (95% CI, 0.36 to 0.56)

Abbreviations. AGB: adjustable gastric banding; BMI: body mass index; BP: blood pressure; BPD: biliopancreatic diversion; BPD-DS: biliopancreatic diversion with duodenal switch; CG: control group; CI: confidence interval; GP: gastric plication; HbA1c: glycated hemoglobin; HR: hazard ratio; HTN: hypertension; IG: intervention group; MBS: metabolic and bariatric surgery; MD: mean difference; MGB: mini gastric bypass; mmHg: millimeters of mercury; MT: medical therapy; NR: not reported; OR: odds ratio; OS: observational studies; RCT: randomized controlled trial; ROB: risk of bias; RR: relative risk; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; Surg: surgery; T2DM: type 2 diabetes mellitus; WMD: weighted mean difference.

Table D5. Additional Study Characteristics of Included RCTs of Adults with BMI 30 to 34.9

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
Parikh, 2014 Moderate	N = 57 5 years	Patients with T2DM and BMI 30 to 35 who were otherwise eligible for bariatric surgery by NIH criteria	(1) Overweight for at least 5 years, (2) failure to lose weight with non-surgical means, (3) absence of medical or psychological contraindications, (4) patient understanding of the procedure and its risks, and (5) strong motivation to comply with the post-surgical regimen	(1) Unable to comply with the study protocol (either self-selected or by indicating during screening that s/he could not complete all requested tasks), (2) participation in other obesity- or diabetes-related clinical trials, or (3) diagnosis of cognitive dysfunction or significant psychiatric comorbidity	Intensive MWM Protocol: MWM sessions were held weekly for the first month and then biweekly. In these 30-minute sessions, the clinician offered culturally tailored, patient-specific counseling on diet, physical activity, self-monitoring, and goal setting. The visits included a review of home glucose data and adjustment of diabetes medications. In addition, participants were provided with pedometers to track their progress, with a goal of 150 minutes per week of low-impact physical activity by 6 months.	IG: 79% CG: 79%	IG: 93% CG: 93%
Ikramuddin, 2013 DSS Trial Low	N = 120 5 years	Individuals who had an HbA1c level of ≥ 8.0%, BMI between 30 and 39.9 kg/m², C peptide level of >1.0 ng/mL, and T2DM for at least 6 months	Patients were included if they were (1) aged 30 through 67 years, (2) under a physician's care for T2DM for at least 6 months before recruitment, (3) had HbA1c levels of ≥ 8.0% at the time of entry, and (4) had a serum C-peptide level > 1.0 ng/mL 90 minutes after a liquid mixed meal. (5) Participants had a BMI of 30.0 to 39.9 and (6) were willing to accept randomization to either	Conditions that would contraindicate surgery, such as (1) serious cardiovascular disease, (2) previous gastrointestinal surgery, (3) psychological concerns, or (4) history of malignancy	The lifestyle-medical management protocol consisted of 2 components: (1) lifestyle modification designed to produce maximum achievable weight loss including daily weigh-ins, tracking food intake and physical activity, structured diets, and counseling, and (2) medications to control glycemia and cardiovascular disease risk factors while facilitating weight loss. Only FDA–approved medications were used (i.e., orlistat, metformin, sulfonylurea or pioglitazone, insulin, aspirin, ACE or ARB inhibitors, and beta blockers).	IG: 63% CG: 57%	IG: 45% CG: 50%

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
			treatment group and follow the full treatment protocol.				
Courcoulas, 2014 TRIABETES Moderate	N = 61 5 years	Adults with grades I and II obesity and T2DM	Participants were eligible for enrollment if they were (1) 25 to 55 years of age, (2) had a BMI of 30 to 40, and (3) had confirmed T2DM (i.e., documented FPG level of ≥ 126 mg/dL and/or treatment with antidiabetics) For participants with grade I obesity, treatment with antidiabetics and permission from their treating physician were required to participate	(1) Prior weight loss surgery, (2) impaired mental status, (3) alcohol or other drug addiction, (4) current smoking, (5) pregnancy or planned pregnancy, (6) inability to tolerate general anesthesia owing to poor health, (7) type 1 diabetes, (8) failed nutritional or psychological assessment, (9) unwillingness to be randomized, (10) inability to provide informed consent, or (11) being deemed unlikely to comply with study visits or procedures	Participants randomized to MT underwent a standard 12-month behavioral weight control program delivered using an in-person, individual format based on the intervention developed for the Diabetes Prevention Program. During the initial 6 months of treatment, LWLI participants attended weekly in-person intervention sessions. During months 7 to 12, they attended in-person sessions in the first and third weeks of the month and received brief telephone contacts in the second and fourth weeks. Each session focused on a specific behavioral topic related to weight loss, eating, or exercise behaviors. Participants were provided with supplemental written materials and were asked to self-monitor body weight, eating, and exercise. Lower-level lifestyle weight loss interventions were then delivered for 4 years.	RYGB: 79% MT: 83%	% African American RYGB: 33% MT: 17%
Liang, 2013 Moderate	N = 108 1 year	Obese people with T2DM and hypertension	Individuals with T2DM diagnosed according to WHO criteria Other inclusion criteria were: (1) BMI > 28 kg/m^2	(1) People without diabetes; (2) type 1 diabetes, presence of autoimmune diabetes indicated by antibodies to insulin, islet cells, and	USUAL CARE: Patients were assessed and treated by a multidisciplinary team that included an endocrinologist, a dietitian, a cardiologist, and a nurse. The dose of oral hypoglycemic medications, antihypertensive drugs	RYGB: 29% MT: 33% MT+E: 29%	RYGB: 100% MT: 100% MT+E: 100%

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
			in accordance with the WHO Asia-Pacific classification for obesity; (2) T2DM with hypertension of 5–10 years with hypertension defined as systolic blood pressure 140 mmHg and/or diastolic blood pressure 90 mmHg as per 1999 WHO/ISH criteria; (3) insulin therapy in combination with oral administration of drugs for 12 months; (4) HbA1c > 7% (5) age: 30–60 years; (6) seronegative for antibodies against insulin, islet cells and GAD; (7) C-peptide level 0.3 mg/L	GAD, and gestational diabetes; (3) patients with heart, liver, or renal function impairment; (4) presence of severe infections or cerebrovascular disease; (5) fasting serum insulin was less than one-third of the normal value; (6) diabetes of more than 10 years duration; (7) age > 60 years or < 30 years	and insulin was optimized on an individual basis with the aim of reaching HbA1c < 7% and blood pressure 140/90 mmHg. The nutrition goal was based on an individual energy intake and reducing fat intake to < 30%, saturated fat to < 10%, and increasing high fiber intake and for physical exercise 30 minutes of moderate-intensity aerobic activity twice a week. USUSAL CARE + EXENATIDE: Exenatide (an antidiabetic medication used to lower blood sugar) was given 1 hour before breakfast or dinner. Patients were injected with 0.5 mg Exenatide subcutaneously twice daily for 1 month, then increased to 1.0 mg twice daily if tolerated.		
Schauer, 2012 STAMPEDE Low	N = 150 5 years	Obese patients with uncontrolled T2DM	(1) Age of 20 to 60 years, (2) a diagnosis of type 2 diabetes (HbA1c level, > 7.0%), (3) and a BMI of 27 to 43	(1) Previous bariatric surgery or other complex abdominal surgery; (2) poorly controlled medical or psychiatric disorders	All patients received intensive medical therapy, as defined by ADA guidelines, including lifestyle counseling, weight management, frequent home glucose monitoring, and the use of newer drug therapies (e.g., incretin analogues) approved by the FDA. All patients were treated with lipid-lowering and antihypertensive medications. Every 3 months for the first 12 months, patients returned for study visits with a	RYGB: 58% SG: 78% MT: 62%	RYGB: 26% SG: 28% MT: 26%

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
					diabetes specialist at the Cleveland Clinic.		
Cohen, 2020 MOMS Moderate	N = 100 2 years	Patients with early-stage CKD, T2DM, and Class I obesity (BMI 30 to 35)	(1) Age: 18–65 years; (2) BMI: 30–34.9 kg/m^2; (3) < 15 years of history of T2DM; (4) Negative GAD autoantibodies test; (5) Fasting C peptide over 1 ng/mL; (6) Appropriate postprandial C peptide response after a 500 kcal mixed meal challenge	(1) Autoimmune diabetes or type 1 diabetes; (2) Previous abdominal operations that would complicate an RYGB; (3) Pregnancy or women of childbearing age without an effective contraceptive; (4) Alcoholism or illicit drug use; (5) Severe hepatic disease that may complicate RYGB; (6) Inflammatory bowel disease or malabsorptive syndrome; (7) Major cardiovascular event in the past 6 months; (8) Current angina; (9) Severe psychiatric disorders that would complicate follow-up after RYGB; (10) Use of immunosuppressive drugs, chemotherapy and/or radiotherapy; (11) Uncontrolled coagulopathy; (12) Advanced proliferative retinopathy with or without amaurosis; (13) CKD stage 4 or 5 waiting for renal replacement therapy; (14) Stage 3	Best medical treatment: medical treatment algorithms in our protocol were consistent with the updated 2019 ADA and European Association for Study of Diabetes guidelines. Behavioral interventions included counseling with a dietician to reduce food intake and increase physical activity. Pharmacology included T2DM medications, ARBs/ACE inhibitors, statins, and antihypertensives.	RYGB: 45% MT: 45%	RYGB: 10% MT: 31%

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
				peripheral neuropathy; (15) Pulmonary embolism in the past 2 years			

Abbreviations. ACE: angiotensin-converting enzyme; ADA: American Diabetes Association; ARB: angiotensin receptor blockers; BMI: body mass index; CG: control group; CKD: chronic kidney disease; DSS: diabetes surgery study; FDA: US Food and Drug Administration; FPG: fasting plasma glucose; HbA1c: glycated hemoglobin; kcal: kilocalories; IG: intervention group; kg/m^2: kilograms per meters squared; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; MT+E: medical therapy and exenatide; NIH: National Institutes of Health; RCT: randomized controlled trials; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy; STAMPEDE: Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently; T2DM: type 2 diabetes; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes; WHO: World Health Organization.

Table D6. Outcomes in Adults with BMI 30 to 34.9: Weight Change, Quality of Life, Harms

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
Parikh, 2014 Moderate	N = 57 5 years	BMI, mean Baseline – IG: 32.8 (1.5), CG: 32.0 (2.2); *P* = .16 3 years – IG: 26.6, CG: 31.1; *P* < .001 5 years – IG: 25.8 (3.1), CG: 28.6 (3.6); *P* = .013 Change – IG: –7.0 (3.2), CG: –3.4 (2.6); *P* < .001 Subgroup: surgery type SG: n = 18, RYGB: n = 8, AGB: n = 3 Baseline – SG: 32.8 (1.7), RYGB: 32.8 (1.2), AGB: 33.0 (.8); *P* = .96 5 years – SG: 27.0 (2.4); RYGB: 24.3 (2.7), AGB: 23.1 (5.4); *P* = .03 Change – SG: –5.9 (1.9), RYGB: –8.6 (3.4), AGB: –9.9 (5.8); *P* = .03 % WEIGHT LOSS 3 years – IG: 26.6%, CG: 2.8%; *P* < .001 5 years – IG: 21.4% (9.4), CG: 10.3% (8.1); *P* = .025 Subgroup: surgery type SG: 18.0 (6.0) RYGB: 26.0 (10.0) AGB: 29.9 (16.9) *P* = .03 % EXCESS WEIGHT LOSS[a] 3 years – IG: 52.9%, CG: 8.7%; *P* < .001	NR	MORTALITIES 6 months – no deaths 3 years – no deaths 5 years – no deaths SAEs (i.e., life-threatening events) 6 months - none 3 years – none 5 years – none HOSPITAL READMISSIONS or REOPERATIONS (IG only) 30-day: 1 of 29 (3%) –> dehydration Longer-term (> 30-day): 4 of 29 (13%) –> abscess requiring drainage, food impaction causing nausea/vomiting, and dehydration/abdominal pain 5 years – 11 of 29 (38%) -> cholecystectomy (n = 4), endoscopy (n = 2), dehydration, B12 deficiency, small bowel obstruction, pancreatitis, and right hemicolectomy for incidentally diagnosed cancer DIABETIC RETINOPATHY 5 years – IG: 0 of 29 (0%), CG: 4 of 14 (29%) PERIPHERAL NEUROPATHY 5 years – IG: 0 of 29 (0%), CG: 6 of 14 (43%)
Ikramuddin, 2013 DSS Trial	N = 120 5 years	BMI, mean Baseline - RYGB: 34.9 (34.1 to 35.7), MT: 34.4 (33.5 to 35.2)	NR	AEs Clinically significant (years 1 to 2) MT: 19

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
Low		1 year RYGB: 25.8 (25.09 to 26.6), MT: 31.6 (30.8 to 32.4) MD, −5.8 (−7.0 to −4.7), *P*< .001 2 years RYGB: 26.8 (25.7 to 27.4), MT: 31.9 (31.0 to 32.7) MD, −5.3 (−6.5 to −4.1), *P*< .001 3 years RYGB: 27.3 (26.5 to 28.1), MT: 31.5 (30.7 to 32.4) MD, −4.2 (−5.4 to −3.0), *P*< .001 4 years RYGB: 27.5 (26.5 to 28.3), MT: 31.5 (30.6 to 32.3) MD, −4.0 (−5.2 to −2.8), *P*< .001 5 years RYGB: 27.4 (26.5 to 28.2), MT: 31.1 (30.3 to 32.0) MD, −3.7 (−4.9 to −2.5), *P*< .001 % WEIGHT LOSS, mean (Supplement) 1 year RYGB: 26.1 (23.8 to 28.4), MT: 7.8 (5.5 to 10.1) MD, 18.3 (15.0 to 21.5), *P*< .001 2 years RYGB: 23.9 (21.6 to 26.2), MT: 7.3 (5.0 to 9.9) MD, 16.7 (13.4 to 19.9), *P*< .001 3 years RYGB: 22.0 (19.7 to 24.3), MT: 8.5 (5.1 to 10.9) MD, 13.5 (10.2 to 16.8), *P*< .001 4 years RYGB: 21.7 (19.4 to 24.0), MT: 8.7 (6.2 to 11.1) MD, 13.0 (9.7 to 16.4), *P*< .001 5 years RYGB: 21.8 (19.5 to 24.1), MT: 9.6 (7.2 to 12.0) MD, 12.2 (8.9 to 15.5), *P*< .001		RYGB: 40 - Most of the first-year adverse events in the RYGB group were directly related to surgery - The RYGB group had 7 serious falls with 5 fractures vs. 3 serious falls and 1 fracture in the MT group - 8 infections occurred in the RYGB group vs. 4 in the MT group Serious (years 3 to 5) MT: 19 RYGB: 26 Total (years 1 to 5) MT: 38 events RYGB: 66 events - The most common AEs were 14 episodes of surgical complications in the gastric bypass group, and 15 and 16 gastrointestinal events in the gastric bypass and lifestyle–medical management groups, respectively - Bone fractures had been previously reported in the gastric bypass group but were not seen in years 3 to 5 NUTRITIONAL DEFICIENCIES Iron deficiency Baseline - MT: 2 of 59 (3%), RYGB: 1 of 60 (2%) 1 year - MT: 4 of 59 (7%), RYGB: 8 of 60 (14%) 2 years - MT: 0 of 59 (0%), RYGB: 11 of 60 (20%); *P*< .01 3 years - NR 4 years - NR

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
				5 years - NR Anemia (blood Hg < 55 mmol/L) Baseline - MT: 0 of 59 (0%), RYGB: 0 of 60 (0%) 1 year - MT: 1 of 59 (2%), RYGB: 3 of 60 (5%) 2 years - MT: 2 of 59 (4%), RYGB: 0 of 60 (0%) 3 years - NR 4 years - NR 5 years - MT: 0 (0%), RYGB: 3 (6%) Vitamin B12 deficiency Baseline - MT: 0 of 59 (0%), RYGB: 2 of 60 (3%) 1 year - MT: 3 of 59 (6%), RYGB: 1 of 60 (2%) 2 years - MT: MT: 1 of 59 (2%), RYGB: 5 of 60 (9%) 3 years - NR 4 years - NR 5 years - MT: 1 (3%), RYGB: 2 (4%) Vitamin D deficiency (< 6.7 nmol/L) Baseline - MT: 12 of 59 (28%), RYGB: 15 of 60 (34%) 1 year - MT: 6 of 59 (15%), RYGB: 11 of 60 (27%) 2 years - MT: 5 of 59 (15%), RYGB: 7 of 60 (18%) 3 years - NR 4 years - NR 5 years - NR
Courcoulas, 2014 TRIABETES Moderate	N = 61 5 years	MEAN WEIGHT CHANGE (kg) Baseline - RYGB: 99.27 (2.99), MT: 102.0 (3.19) 1 year - RYGB: −28.8 (1.68), MT: −7.52 (1.95); *P* < .001 3 years - RYGB: −24.6 (2.12), MT: −5.03 (2.53); *P*	NR	TOTAL AEs (through 5 years) RYGB: 21 events MT: 14 events DEATHS

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		< .001 5 years - RYGB: −24.9 (2.12), MT: −4.50 (2.51); *P* < .001 % WEIGHT CHANGE Baseline - N/A 1 year - RYGB: −29.1 (1.64), MT: −7.59 (2.00); *P* < .001 3 years - RYGB: −25.0 (2.04), MT: −5.7 (2.42); *P* < .001 5 years - RYGB: −25.2 (2.09), MT: −5.14 (2.46); *P* < .001 MEAN BMI CHANGE (kg/m2) Baseline - RYGB: 35.67 (0.61), MT: 35.75 (0.73) 1 year - RYGB: −10.2 (0.59), MT: −2.38 (0.69); *P* < .001 3 years - RYGB: −8.70 (0.72), MT: −1.75 (0.82); *P* < .001 5 years - RYGB: −8.75 (0.76), MT: −1.20 (0.85); *P* < .001		RYGB: no deaths MT: no deaths SAEs Post-operative SAE (< 30 days) - RYGB: 0 Late-operative SAE (> 30 days) - RYGB: 1 event (anastomotic ulcer) Non-operative SAE (> 30 days) - RYGB: 0; MT 0 NON-SERIOUS AEs Post-operative AE (< 30 days) - RYGB: 3 (2 prolonged hospital stay, 1 nausea requiring IV hydration) Late-operative AE (> 30 days) - RYGB: 1 (reoperation) Non-operative AE (> 30 days) - RYGB: 16; MT: 14
Liang, 2013 Moderate	N = 108 1 year	MEAN BMI Baseline - RYGB: 30.48 (0.94), MT: 30.94 (1.96), MT+E: 30.28 (1.44) 1 year - RYGB: 24.51 (0.91), MT: 30.38 (1.66), MT+E: 26.84 (1.21)* RYGB vs. MT: *P*< .01 RYGB vs. MT+E: *P*< .05	NR	- There were no SAEs observed in any of the three groups - The patients in group B (38%) had a higher incidence of vomiting than group A (8%) and nausea in group C (16%) - 6 patients in group C developed local inflammation around the drainage port and all were successfully treated using conservative regimens
Schauer, 2012 STAMPEDE Low	N = 150 5 years	Figure S4 in 5-yr supplement visualizes changes in BMI stratified by baseline BMI group (above or below 35), but yearly means are not reported	NR	NR

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
Cohen, 2020 MOMS Moderate	N = 100 2 years	MEAN BMI Baseline - RYGB: 32.5 (1.9), MT: 32.6 (2.1) 2 years - RYGB: 24.5 (23.5 to 25.0), MT: 31.2 (30.5 to 32.0) MD, −6.9 (−8.0 to −5.8); *P* < .001 BMI IN NORMAL RANGE, % RYGB: 51% MT: 0% *P* < .001 % WEIGHT CHANGE RYGB: −25.4% (−26.9 to −23.8) MT: −4.5% (−6.1 to −3.1) LOST ≥ 15% BODY WEIGHT RYGB: 95% MT: 5%	SF-36 SCORES[b], points General Health RYGB: 78.15 (72.6 to 83.7) MT: 60.3 (54.8 to 65.8) MD, 17.85 (10.0 to 25.7); *P* < .001 Emotional Well-being RYGB: 71.9 (66.2 to 77.8) MT: 63.0 (57.2 to 68.8) MD, 8.9 (0.7 to 17.2); *P* = .03 Physical Health RYGB: 80.4 (68.8 to 92.1) MT: 60.5 (48.9 to 72.1) MD, 19.9 (3.5 to 36.4); *P* = .02 Physical Role Functioning RYGB: 84.3 (77.9 to 90.7) MT: 70.2 (63.8 to 76.6) MD, 14.2 (5.1 to 23.2); *P* = .002 Mental Health RYGB: 73.5 (61.5 to 85.6) MT: 62.6 (50.6 to 74.7) MD not reported; *P*.=.21 Vitality RYGB: 69.5 (63.6 to 75.4) MT: 55.1 (49.2 to 61.0) MD, 14.4 (6.1 to 22.7); *P* = .001	SAEs RYGB: 6 of 46 (13%) MT: 6 of 46 (13%) *P* > .99 - RYGB group: 1 case of sepsis due to osteomyelitis, 1 case of appendicitis, 1 case of gall stones, 1 case of intestinal bleeding, and 2 endoscopic interventions - MT group: 1 case each of kidney stones, chest pain, anaphylactic shock, erysipelas, septic shock due to foot infection, and diabetic foot infection MOST COMMON AEs - GI/abdominal pain - Hypoglycemia - Diarrhea - Vomiting - Musculoskeletal pain OTHER AEs - No deaths, episodes of serious hypoglycemia, malnutrition, or excessive weight loss occurred

Notes. [a] Excess weight loss was calculated based on the Robinson formula for ideal body weight. [b] 24-month scores reported for measures where the study groups did not differ at baseline (measures not reported due to imbalance at baseline: pain, social role function, and mental health).

Abbreviations. AE: adverse event; AGB: adjustable gastric banding; BMI: body mass index; CG: control group; DSS: diabetes surgery study; GI: gastrointestinal; IG: intervention group; kg: kilograms; kg/m^2: kilograms per meters squared; MD: mean difference; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; MT+E: medical therapy and exenatide; NR: not reported;

RYGB: Roux-en-Y gastric bypass; SAE: serious adverse event; SF-36: Short Form-36 survey; SG: sleeve gastrectomy; STAMPEDE: Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Table D7. Outcomes in Adults with BMI 30 to 34.9: T2DM, Hypertension, Coronary Artery Disease

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
Parikh, 2014 Moderate	N = 57 5 years	T2DM REMISSION[a] 3 years – IG: 19 of 30 (63%), CG: 0 of 14 (0%); *P* < .001 5 years – IG: 11 of 29 (38%), CG: 0 of 14 (0%); *P* = .008 SG: 7 of 18 (39%), RYGB: 4 of 8 (50%), AGB: 0 of 3 (0%) MEAN HbA1c Baseline – IG: 7.50 (1.17), CG: 7.46 (.94); *P* = .91 3 years – IG: 6.91, CG: 8.37; *P* < .001 5 years – IG: 6.93 (1.37), CG: 8.26 (1.80); *P* = .01 Change – IG: −0.57 (1.40), CG: +0.81 (1.47); *P* = .006 Subgroup: surgery type Baseline – SG: 7.39 (1.33), RYGB: 7.66 (.93), AGB: 7.73 (.80); *P* = .83 5 years – SG: 6.91 (1.25), RYGB: 6.67 (1.60), AGB: 7.63 (1.82); *P* = .61 Change – SG: −0.48 (1.48), RYGB: −0.99 (1.28), AGB: −0.10 (1.51); *P* = .62 CHANGE IN USE OF DIABETES MEDICATIONS 3 years – IG: -1.33, CG: +0.13; *P* < .001 % USING INSULIN 5 years – IG: 3 of 29 (10%), CG: 7 of 14 (50%); *P* = .007 –> SG: 2 of 18 (11%), RYGB: 0 of 8 (0%), AGB: 1 of 3 (33%); *P* = .39	% USING ANY HTN MEDS SG: 11 of 18 (61%) RYGB: 4 of 8 (50%) AGB: 2 of 3 (67%) *P* = .59 % USING > 1 HTN MEDS –> SG: 6 of 18 (33%), RYGB: 1 of 8 (13%), AGB: 1 of 3 (33%); *P* = .48 SBP, mean (SD) Baseline – IG: 129.1 (15.5), CG: 128.9 (23.2), *P* = .98 5 years – IG: 132.8 (20.2), CG: 135.6 (17.5), *P* = .66 Change – IG: +3.75 (23.8), CG: +6.7 (25.3), *P* = .71 Subgroup: surgery type Baseline – SG: 133.0 (15.3), RYGB: 124.1 (15.5), AGB: 120.3 (14.7); *P* = .25 5 years – SG: 143.8 (14.8), RYGB: 111.4 (8.8), AGB: 128.0 (26.3); *P* < .001 Change – SG: +10.8 (20.6), RYGB: −12.7 (20.4), AGB: +7.7 (35.5); *P* = .06 DBP, mean (SD) Baseline – IG: 79.2 (12.6), CG: 72.9 (6.2), *P* = .03 5 years – IG: 76.7 (10.6), CG: 74.4 (10.3), *P* = .52 Change – IG: −2.5 (14.9), CG: +1.6 (13.4), *P* = .39	Not abstracted: – Triglycerides – Cholesterol – HDL – LDL

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
		T2DM IMPROVEMENT[b] 3 years – IG: 27 of 30 (90%), CG: 3 of 14 (21%); *P*< .001 T2DM WORSENING[c] 3 years – IG: 1 of 30 (0.03%), CG: 8 of 14 (57%); *P*< .001	Subgroup: surgery type Baseline – SG: 81.4 (13.3), RYGB: 76.8 (9.4), AGB: 73.3 (18.0); *P*= .50 5 years – SG: 79.7 (10.5), RYGB: 73.1 (10.1), AGB: 68.7 (6.0); *P*= .13 Change – SG: –1.7 (14.1), RYGB: –3.6 (17.0), AGB: –4.7 (20.1); *P*= .93	
Ikramuddin, 2013 DSS Trial Low	N = 120 5 years	T2DM REMISSION[d] Full or partial remission Baseline - N/A I year - N/A 2 years - MT: 0% (0 to 7), RYGB: 36% (16 to 61); *P*< .001 3 years - MT: 0% (9 to 8, RYGB:) 35% (16 to 60); *P*< .001 4 years - MT: 5% (1 to 16), RYGB: 32% (14 to 57); *P*< .001 5 years - MT: 5% (1 to 16), RYGB: 16% (6 to 36); *P*= .003 Full remission Baseline - N/A I year - N/A 2 years - MT: 0% (0 to 7), RYGB: 16% (7 to 33); *P*< .001 3 years - MT: 0% (9 to 8), RYGB: 12% (5 to 28); *P*= .002 4 years - MT: 0% (0 to 8) , RYGB: 11% (4 to 25); *P*= .004 5 years - MT: 0% (0 to 8), RYGB: 7% (2 to 19); *P* = .02 USING INSULIN	% USING ANTIHYPERTENSIVES Baseline - MT: 41 of 56 (73%), RYGB: 38 of 57 (67%) 1 year - MT: 71% (58 to 83), RYGB: 37% (24 to 51) OR, 0.02 (0.00 to 0.13); *P*< .001 2 years - MT: 63% (49 to 76), RYGB: 39% (26 to 53) OR, 0.11 (0.02 to 0.55); *P*= .01 3 years - MT: 61% (45 to 76), RYGB: 38% (25 to 52) OR, 0.14 (0.03 to 0.73); *P*= .03 4 years - MT: 62% (46 to 76), RYGB: 44% (31 to 59) OR, 0.19 (0.03 to 1.08); *P*= .10 5 years - MT: 67% (51 to 81), RYGB: 47% (34 to 61) OR, 0.14 (0.02 to 0.84); *P*= .06 SYSTOLIC BLOOD PRESSURE SBP < 130 mmHg Baseline - MT: 25 of 56 (45%), RYGB: 29 of 57 (51%) 1 year - MT: 85% (71 to 93), RYGB: 89% (78 to 95) OR, 1.52 (0.46 to 4.98); *P*= .49	% WITH LDL-C < 100 mg/dL Baseline - MT: 54% (40 to 67), RYGB: 51% (37 to 64) OR, 0.90 (0.43 to 1.88); *P*= .78 1 year - MT: 74% (58 to 86), RYGB: 84% (70 to 92) OR, 1.77 (0.60 to 5.20); *P*= .30 2 years - MT: 77% (61 to 88), RYGB: 81% (67 to 90) OR, 1.28 (0.43 to 3.79); *P*= .65 3 years - MT: 56% (37 to 73), RYGB: 73% (56 to 85) OR, 2.10 (0.72 to 6.09); *P*= .17 4 years - MT: 54% (34 to 72), RYGB: 69% (52 to 83) OR, 1.95 (0.66 to 5.78); *P*= .23 5 years - MT: 47% (29 to 67), RYGB: 77% (61 to 88) OR, 3.66 (1.22 to 11.00); *P*= .02 TRIGLYCERIDES, mg/dL Baseline - MT: 250 (191 to 309), RYGB: 258 (154 to 362) 1 year - MT: 181 (140 to 222), RYGB: 104 (64 to 144) MD, −77 (−134 to −19); *P*= .01

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
		Baseline - MT: 43% (29 to 56), RYGB: 61% (48 to 74) 1 year MT: 43% (30 to 57), RYGB: 18% (9 to 30) OR, 0.10 (0.02 to 0.54); *P*= .004 2 years - MT: 44% (31 to 59), RYGB: 18% (9 to 30) OR, 0.08 (0.01 to 0.46); *P*= .004 3 years - MT: 45% (30 to 61), RYGB: 15% (6 to 27) OR, 0.04 (0.01 to 0.28); *P*= .001 4 years - MT: 36% (22 to 52), RYGB: 13% (5 to 25) OR, 0.06 (0.01 to 0.41); *P*= .01 5 years - MT: 37% (23 to 53), RYGB: 15% (6 to 27) OR, 0.07 (0.01 to 0.44); *P*= .02 USING NONINSULIN T2DM MEDICATION Baseline - MT: 53 of 56 (95%), RYGB: 49 of 57 (86%) 1 year - MT: 98% (90 to 100), RYGB: 35% (23 to 49) OR, 0.00 (0.00 to 0.02); *P*< .001 2 years - MT: 93% (82 to 98), RYGB: 43% (30 to 57) OR, 0.02 (0.00 to 0.12); *P*< .001 3 years - MT: 84% (70 to 93), RYGB: 42% (29 to 56) OR, 0.06 (0.01 to 0.27); *P*< .001 4 years - MT: 90% (77 to 97), RYGB: 41% (28 to 55) OR, 0.02 (0.00 to 0.14); *P*< .001 5 years - 88% (75 to 96), RYGB: 42% (29 to 56)	2 years - MT: 78% (62 to 88), RYGB: 88% (76 to 95) OR, 2.20 (0.70 to 6.95); *P*= .18 3 years - MT: 56% (38 to 73), RYGB: 79% (64 to 89) OR, 2.90 (0.99 to 8.48); *P*= .05 4 years - MT: 65% (45 to 80), RYGB: 79% (63 to 89) OR, 2.04 (0.68 to 6.13); *P*= .20 5 years - MT: 49% (31 to 68), RYGB: 73% (56 to 85) OR, 2.71 (0.95 to 7.78); *P*= .06 SBP < 140 mmHg Baseline - MT: 39 of 56 (70%), RYGB: 46 of 57 (81%) 1 year - MT: 96% (87 to 99), RYGB: 97% (89 to 99) OR, 1.49 (0.24 to 9.07); *P*= .67 2 years - MT: 92% (81 to 97), RYGB: 97% (88 to 99) OR, 2.38 (0.44 to 12.71); *P*= .31 3 years - MT: 82% (65 to 92), RYGB: 97% (88 to 99) OR, 5.90 (1.17 to 29.76); *P*= .03 4 years - MT: 81% (63 to 92), RYGB: 97% (88 to 99) OR, 6.39 (1.25 to 32.61); *P*= .03 5 years - MT: 86% (69 to 94), RYGB: 92% (80 to 97) OR, 1.92 (0.47 to 7.91); *P*= .37 Mean SBP, mmHg Baseline - MT: 132 (129 to 136) 127 (123 to	2 years - MT: 258 (217 to 299), RYGB: 109 (68 to 149) MD, −149 (−207 to −92); *P*< .001 3 years - MT: 237 (192 to 282), RYGB: 110 (70 to 151) MD, −127 (−187 to −66); *P*< .001 4 years - MT: 196 (150 to 242), RYGB: 111 (70 to 152) MD, −85 (−147 to −23); *P*= .01 5 years - MT: 183 (137 to 228), RYGB: 116 (75 to 157) MD, −66 (−127 to −6); *P*= .03

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
		OR, 0.04 (0.01 to 0.19); *P* < .001 HBA1C HbA1C < 7.0% Baseline - MT: 0%, RYGB: 0% 1 year MT: 29% (15 to 47), RYGB: 83% (67 to 92) OR, 12.29 (3.78 to 39.96); *P* < .001 2 years MT: 18% (9 to 35), RYGB: 85% (69 to 93) OR, 24.42 (7.03 to 84.90); *P* < .001 3 years MT: 4% (5 to 30), RYGB: 58% (38 to 76) OR, 8.89 (2.46 to 32.10); *P* = .001 4 years MT: 6% (2 to 18), RYGB: 59% (39 to 76) OR, 21.51 (5.00 to 92.57); *P* < .001 5 years MT: 14% (6 to 31), RYGB: 55% (36 to 73) OR, 7.51 (2.07 to 27.28); *P* = .002 HbA1C < 6.0% Baseline - MT: 0%, RYGB: 0% 1 year - MT: 5% (2 to 16), RYGB: 45% (26 to 65) OR, 13.94 (3.17 to 61.28); *P* = .001 2 years - MT: 3% (1 to 11), RYGB: 35% (18 to 57) OR, 18.25 (3.32 to 100.4); *P* = .001 3 years - MT: 4% (1 to 16), RYGB: 20% (9 to 39) OR, 5.52 (0.97 to 31.49); *P* = .05 4 years - MT: 3% (1 to 13), RYGB: 15% (6 to 32) OR, 6.51 (0.92 to 46.06); *P* = .06 5 years - MT: 3% (0 to 13), RYGB: 11% (4 to 26)	131) 1 year - MT: 123 (120 to127), RYGB: 115 (112 to 119) MD, -8 (-13 to -3); *P* = .002 2 years - MT: 124 (121 to 127), RYGB: 118 (115 to 122) MD, -6 (-10 to -1); *P* = .02 3 years - MT: 129 (125 to 132), RYGB: 122 (119 to 126) MD, -7 (-12 to -2); *P* = .01 4 years - MT: 129 (125 to 132), RYGB: 122 (118 to 125) MD, -7 (-12 to -2); *P* = .01 5 years - MT: 130 (126 to 134), RYGB: 124 (121 to 127) MD, -6 (-11 to -1); *P* = .02 DIASTOLIC BLOOD PRESSURE Mean DBP, mmHg Baseline - MT: 79 (76 to 82), RYGB: 78 (74 to 81) 1 year - MT: 74 (72 to 76), RYGB: 68 (66 to 71) MD, −6 (−9 to −3); *P* < .001 2 years - MT: 75 (73 to 78), RYGB: 70 (67 to 72) MD, −6 (−9 to −2); *P* = .001 3 years - MT: 77 (74 to 79), RYGB: 71 (69 to 73) MD, −5 (−9 to −2); *P* = .002 4 years - MT: 76 (74 to 79), RYGB: 72 (70 to 74) MD, −4 (−8 to −1); *P* = .01 5 years - MT: 77 (74 to 80), RYGB: 73 (70 to 75) MD, −4 (−8 to −1); *P* = .01	

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
		OR, 4.62 (0.64 to 33.13); *P* = .13 Mean HbA1c % Baseline - MT: 9.6 (1.2), RYGB: 9.6 (1.0) 1 year - MT: 7.8 (7.4 to 8.2), RYGB: 6.3 (5.9 to 6.7) MD, -1.5 (-2.0 to -0.9); *P* < .001 2 years - MT: 8.4 (8.0 to 8.8), RYGB: 6.4 (6.0 to 6.8) MD, -1.9 (-2.5 to -1.4); *P* < .001 3 years - MT: 8.7 (8.3 to 9.1), RYGB: 6.7 (6.3 to 7.1) MD, -2.0 (-2.5 to -1.4) ; *P* < .001 4 years - MT: 9.1 (8.7 to 9.6), RYGB: 7.0 (6.6 to 7.4) MD, -2.2 (-2.7 to -1.6); *P* < .001 5 years - MT: 8.7 (8.3 to 9.1), RYGB: 7.1 (6.7 to 7.5) MD, -1.6 (-2.2 to -1.0) ; *P* < .001		
Courcoulas, 2014 TRIABETES Moderate	N = 61 5 years	T2DM REMISSION[e] Partial or complete remission* Baseline - N/A 1 year - RYGB: 12 of 20 (60%), MT: 0 of 20 (0%); *P* < .001 3 years - RYGB: 8 of 20 (40%), MT: 0 of 20 (0%); *P* = .04 5 years - RYGB: 6 of 20 (30%), MT: 0 of 20 (0%); *P* = .02 Complete remission[f] Baseline - N/A 1 year - RYGB: 4 of 20 (20%), MT: 5 of 20 (25%); *P* = .11 3 years - RYGB: 3 of 20 (15%), MT: 0 of 20 (0%)	SBP, mean (mmHg) Baseline - RYGB: 139.7 (2.74), MT: 132.0 (4.00) 1 year - RYGB: −17.3 (3.58), MT: −10.6 (3.91); *P* = .31 3 years - RYGB: −13.0 (4.09), MT: −0.24 (4.58); *P* = .03 5 years - RYGB: –19.5 (4.76), MT: –1.70 (5.03); *P* = .008 DBP, mean (mmHg) Baseline - RYGB: 81.27 (2.14), MT: 76.28 (2.15) 1 year - RYGB: −7.02 (1.82), MT: −4.36 (1.97); *P* = .17 3 years - RYGB: −5.44 (1.82), MT: −2.87 (2.03); *P* = .32	LDL-C Baseline - RYGB: 117.8 (10.63) 105.5 (7.45) 1 year - RYGB: −13.1 (7.41) −11.2 (8.36); *P* = .44 3 years - RYGB: −0.50 (7.96) −7.66 (9.42); *P* = .54 5 years - RYGB: –9.43 (8.28) –19.3 (8.25); *P* = .39 TRIGLYCERIDES Baseline - RYGB: 169.7 (27.16) 161.2 (24.52) 1 year - RYGB: −107 (10.64) −35.2 (11.88); *P* = .19 3 years - RYGB: −95.3 (17.11) −16.9 (20.53); *P* = .002

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
		5 years - RYGB: 1 of 20 (5%), MT: 0 of 20 (0%) DIABETES MEDICATION USE[g] Baseline - RYGB: 20 of 20 (100%), MT: 20 of 20 (100%) 1 year - RYGB: 4 of 18 (22%), MT: 14 of 14 (100%); $P < .001$ 3 years - RYGB: 5 of 18 (28%), MT: 13 of 13 (100%); $P < .001$ 5 years - RYGB: 7 of 16 (44%), MT: 14 of 14 (100%); $P < .001$ MEAN HbA1c CHANGE Baseline - RYGB: 8.56 (0.46), MT: 7.03 (0.17) 1 year - RYGB: −1.88 (0.35), MT: −0.21 (0.40); $P < .001$ 3 years - RYGB: −1.42 (0.34), MT: +0.21 (0.40); $P < .001$ 5 years - RYGB: −1.46 (0.39), MT: +0.77 (0.42); $P < .001$	5 years - RYGB: −6.92 (2.42), MT: −0.60 (2.56); $P = .07$	5 years - RYGB: −78.0 (13.74) −9.33 (14.75); $P < .001$
Liang, 2013 Moderate	N = 108 1 year	DIABETES REMISSION AT 1 YEAR RYGB: 28 of 31 (90%) MT: 0 of 36 (0%) MT+E: 0 of 34 (0%) RYGB vs. MT: $P < .01$ RYGB vs. MT+E: $P < .05$ HBA1C Baseline - RYGB: 10.47 (1.17), MT: 10.88 (1.40), MT+E: 10.52 (1.49) 1 year - RYGB: 5.98 (0.30)*, MT: 8.14 (0.27), MT+E: 7.10 (0.26) RYGB vs. MT: $P < .05$ RYGB vs. MT+E: $P < .05$	SBP, mmHg Baseline - RYGB: 160.8 (7.8), MT: 156.6 (11.8), MT+E: 159.9 (8.6) 1 year - RYGB: 126.5 (4.9), MT: 132.4 (5.7)*, MT+E: 130.8 (5.3) Between group comparisons NR	LDL-C, mmol/L Baseline - RYGB: 3.84 (0.63), MT: 3.72 (0.42), MT+E: 3.72 (0.64) 1 year - RYGB: 1.97 (0.45)*, MT: 3.69 (0.48), MT+E: 2.68 (0.33) RYGB vs. MT: $P < .05$ RYGB vs. MT+E: $P < .05$ TRIGLYCERIDES, mmol/L Baseline - RYGB: 3.39 (1.18), MT: 3.49 (1.32), MT+E: 3.56 (1.08) 1 year - RYGB: 1.60 (0.13)*, MT: 3.50 (1.51), MT+E: 2.79 (0.60)

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
				RYGB vs. MT: *P* < .05 RYGB vs. MT+E: *P* < .05
Schauer, 2012 STAMPEDE Low	N = 150 5 years	MEAN HBA1C (participants with BMI < 35) Baseline - Surgery (n = 32): 9.5 (9.1), MT: (n = 17): 8.8 (8.9) 1 year - Surgery: 6.6 (6.7), MT: 7.5 (6.9) 2 years - Surgery: 6.8 (6.8), MT: 7.7 (7.4) 3 years - Surgery: 7.1 (6.7), MT: 8.2 (7.9); *P* = .008 4 years - Surgery: 7.2 (6.8), MT: 8.8 (8.6) 5 years - Surgery: 7.3 (7.1), MT: 8.8 (8.0); *P* < .001	NR	NR
Cohen, 2020 MOMS Moderate	N = 100 2 years	HBA1C Baseline - RYGB: 8.80 (1.86), MT: 8.94 (1.96) 2 years - RYGB: 6.18 (5.80 to 6.56), MT: 6.72 (6.34 to 7.09) Reduction - RYGB: -2.6%, MT: -2.2% MD, −0.54 (−1.07 to −0.004); *P* = .05 HbA1c ≤ 7.0%[h] RYGB: 83.0% (72.4 to 93.60) MT: 70.2% (56.9 to 83.6) MD, 12.7 (−4.3 to 29.7); *P* = .16 HbA1c ≤ 6.5%[i] RYGB: 70.9% (57.8 to 84.0) MT: 50.5% (36.3 to 64.8) MD, 20.4 (1.03 to 39.7); *P* = .05 HbA1c ≤ 6.0%[j] RYGB: 44.5% (29.8 to 59.2) MT: 24.4% (12.3 to 36.7) MD, 20.1 (1.00 to 39.1); *P* = .05	MEAN BP (mmHg) SBP Baseline - RYGB: 141.5 (17.2), MT: 137.3 (15.5) 2 years - RYGB: 130.8 (125.9 to 135.6), MT: 129.9 (125.1 to 134.6) MD, 0.91 (−5.88 to 7.70); *P* = .79 DBP Baseline - RYGB: 88.1 (12.7), MT: 85.7 (8.0) 2 years - RYGB: 79.7 (76.6 to 82.8), MT: 82.5 (79.5 to 85.5) MD, −2.80 (−7.12 to 1.53); *P* = .21 SBP < 130 mm Hg, % RYGB: 32.5 (18.6 to 46.5) MT: 37.8 (23.6 to 51.9) MD, −5.2 (−2.5 to 14.7); *P* = .61 DBP < 80 mm Hg, % RYGB: 28.0 (14.5 to 41.4) MT: 20.1 (8.40 to 31.9) MD, 7.8 (−9.98 to 25.6); *P* = .39	LDL-C Mean LDL-C, mg/dL Baseline - RYGB: 102 (36.5), MT: 108.6 (41.1) 2 years - RYGB: 85.7 (76.3 to 95.0), MT: 101.6 (92.2 to 110.9) MD, −15.9 (−29.1 to −2.65); *P* = .02 LDL-C level <100 mg/dL, % RYGB: 72.6 (59.4 to 85.2) MT: 51.2 (37.1 to 66.5) MD, 20.5 (0.9 to 40); *P* = .05 TRIGLYCERIDES Mean triglycerides, mg/dL Baseline - RYGB: 195 (145 to 293), MT: 214 (150 to 334) 2 years - RYGB: 107.8 (90.6 to 140.3), MT: 180.7 (157.7 to 207.2) MD, −67 (−102.1 to −31.9); *P* < .001 Triglyceride levels < 150 mg/dL, % RYGB: 80.0 (70.2 to 92.6)

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE
		DIABETES MEDICATIONS Median number of metabolic medications at 24 months RYGB: 1 (IQR, 1-3) MT: 6 (IQR, 3-9) *P*< .001 Metformin use at 24 months RYGB: 35of 46 (76.1%) MT: 45 of 46 (97.8%) *P*= .004 Insulin use at 24 months RYGB: 5 of 46 (10.9%) MT: 25 of 46 (54.3% *P*< .001		MT: 41.9 (26.9 to 55.1) MD, 40.4 (22.4 to 58); *P*< .001 CVD MEDICATION USE Beta-blocker use at 24 months RYGB: 6 of 46 (13.0%) MT: 10 of 46 (21.7%) *P*= .41 Calcium channel blocker use at 24 months RYGB: 5 of 46 (10.9%) MT: 10 of 46 (21.7%) *P*= .26 ARB or ACE-inhibitor use at 24 months RYGB: 41 of 46 (89.1%) MT: 40 of 46 (87.0%) *P*= .99

Notes. [a] T2DM was defined based on the ADA criteria: (1) fasting glucose ≥ 126 mg/dL, (2) glucose ≥ 200 at 120 minutes after 75 g oral glucose load, or (3) HbA1c ≥ 6.5%. Diabetes remission was defined as no longer meeting the ADA criteria for T2DM, without the use of diabetes medications. [b] T2DM improvement was defined as reduction in medication use. [c] T2DM worsening was defined as an increase in medication use and/or conversion to insulin from an oral agent or an increase in HbA1C on the same medication. [d] Full diabetes remission is defined as an HbA1c level of less than 6.0% at the 4- and 5-year visits and no use of antihyperglycemic medication at either visit. Partial diabetes remission definition replaced the HbA1c level of 6.0% with 6.5% at the same time points. [e] Missing data at follow-up were assumed to be no remission. [f] Partial remission = no use of antidiabetics, HbA1c level of < 6.5%, and fasting plasma glucose level of ≤ 125 mg/dL
Complete remission = no use of antidiabetics, hemoglobin A1c. Remission (partial or complete) for at least 2 consecutive years. [g] Insulin or other medications (e.g., metformin). [h] ADA definition for good glycemic control. [i] ADA definition for partial T2DM remission. [j] ADA definition for full T2DM remission.

Abbreviations. ACE: angiotensin-converting enzyme; ADA: American Diabetes Association; AGB: adjustable gastric banding; ARB: angiotensin receptor blockers; BMI: body mass index; BP: blood pressure; CG: control group; CVD: cardiovascular disease; DBP: diastolic blood pressure; DSS: diabetes surgery study; HbA1c: glycated hemoglobin; HDL: high-density lipoprotein; HTN: hypertension; IG: intervention group; LDL-C: low density lipoprotein cholesterol; MD: mean difference; mg/dL: milligrams per deciliter; mmHg: millimeters of mercury; mmol/L: millimoles per liter; MOMS: Microvascular Outcomes after Metabolic Surgery; MT: medical therapy; MT+E: medical therapy and exenatide; N/A: not applicable; NR: not reported; OR: odds ratio; RYGB: Roux-en-Y gastric bypass; SBP: systolic blood pressure; SG: sleeve gastrectomy; STAMPEDE: Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently; T2DM: type 2 diabetes; TRIABETES: Randomized Trial to Compare Surgical and Medical Treatments for Type 2 Diabetes.

Table D8. Additional Study Characteristics of Included Adolescent Cohort Studies

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
Inge, 2018 Teen-LABS/TODAY High	N = 93 2 years	Severely obese adolescents with type 2 diabetes	Teen-LABS participants with type 2 diabetes at the time of surgery TODAY participants (irrespective of treatment group assignment) were frequency matched to the 30 Teen-LABS participants with type 2 diabetes using the following matching characteristics: baseline age (13-18 years), race, sex, ethnicity, and baseline BMI (> 35)	NR	Adolescents (ages 10 to 17 years) with T2DM randomized to (1) metformin alone, (2) metformin combined with rosiglitazone, or (3) a lifestyle-intervention program focusing on weight loss through eating and activity behaviors. The 63 included participants in this analysis were from all 3 medically treated arms.	Teen-LABS: 70% TODAY: 44% *P*= .03	Teen-LABS: 40% TODAY: 29% *P*= .06
Inge, 2014 Teen-LABS Moderate	N = 242 3 years	Severely obese adolescents undergoing weight loss surgery	(1) Subjects ≤ 19 years of age who are approved by clinical team and payor to undergo bariatric surgery by a Teen-LABS-certified surgeon, (2) primary caregivers of adolescent participants (for their weight, height, and demographic variables only) An adolescent was not excluded if their caregiver declined participation	(1) Informed consent not obtained from adolescent or the adolescent's legally authorized representative, (2) unable to communicate with local study staff	NA	75.6%	28.1%
Inge, 2017 FABS-5+ High	N = 58 5 to 12 years	Individuals who underwent RYGB for	Age ≤ 21 years at time of bariatric surgery	(1) Inability to complete self-report forms due to developmental delay, or (2)	NA	64%	14%

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	POPULATION	INCLUSION CRITERIA	EXCLUSION CRITERIA	CONTROL GROUP DESCRIPTION	% FEMALE	% NON-WHITE
		clinically severe obesity at 13 to 21 years of age		death prior to long-term study visit			
Olbers, 2012 AMOS Moderate	N = 161 5 years	Adolescents (13–18 years) with a BMI range 36 to 69 kg/m2	Adolescent surgery group: (1) Age 13–18 years, (2) BMI ≥ 40 or ≥ 35 kg/m² with comorbidity (type 2 diabetes, sleep apnea, joint pain, and high blood lipids), (3) pubertal Tanner stage > III and passed peak height growth velocity, (4) participation for ≥ 1 year in a comprehensive weight loss program Adult surgery group: The inclusion age was 35 to 45 years at surgery; all other inclusion and exclusion criteria were similar to adolescents Adolescent MT group: Adolescent controls were selected as conventional treatment comparisons using the same inclusion and exclusion criteria as for the adolescents undergoing surgery; the date of surgery for a surgical patient coincided in time with baseline weight and height registration for a control within ±1 month	All groups: (1) Insufficiently treated psychiatric disorder, (2) ongoing drug abuse, (3) obesity due to syndromes or monogenic disease as clinically assessed (50% had the *MC4* receptor sequenced) or brain injury	Adolescent medical therapy controls were matched from the Swedish Childhood Obesity Treatment Register (BORIS) at the end of the recruitment period of surgical subjects. Controls were selected so that the mean values of the matching variables (BMI, age, and gender) in the control group moved as much as possible in the direction of the mean values in the surgically treated adolescents. The control group was treated with conventional Swedish medical obesity standards. This treatment mainly consists of individualized or family-based counseling and cognitive behavior therapy concerning diet and physical activity. Low-calorie diets and drugs (metformin, orlistat, or sibutramin) were prescribed if found clinically indicated by the treating pediatrician.	RYGB: 65% MT: 57%	NR

Abbreviations. AMOS: Adolescent Morbid Obesity Surgery; BMI: body mass index; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; kg/m^2: kilograms per meters squared; MT: medical therapy; NA: not applicable; NR: not reported; RYGB: Roux-en-Y gastric bypass; T2DM: type 2 diabetes mellitus; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

Table D9. Outcomes in Adolescent Studies: Weight Change, Quality of Life, Harms

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
Inge, 2018 Teen-LABS/TODAY High	N = 93 2 years	BMI (kg/m2) Teen-LABS - BL: 51.8, 2yr: 36.3; MD, −15.1 (−17.3 to −13.0) TODAY - BL: 36.7, 2yr: 37.9; MD, +1.3 (−0.2 to 2.8) *P*< .001 WEIGHT (kg) Teen-LABS - BL: 155.1, 2yr: 110.9; MD, −44.2 (−50.6 to −37.8) TODAY - BL: 117.4, 2yr: 123.2; MD, +5.8 (1.4 to 10.2) *P*< .001	NR	HOSPITALIZATIONS Teen-LABS - 7 of 30 (23%) experienced complications that required subsequent operation and/or readmission that were related or possibly related (e.g., cholecystectomy for gallstones) to their prior bariatric surgery - 5 of 30 (17%) required subsequent hospitalization for observation or other interventions (nonabdominal operations) that were unrelated to the prior bariatric operation TODAY - 2 of 63 (3%) participants required hospital admission; the reasons for these admissions included calf swelling and ankle edema in one TODAY participant, and knee pain and anemia in another
Inge, 2014 Teen-LABS Moderate	N = 242 3 years	MEAN WEIGHT (kg) Overall (n = 228) Baseline: 149 (145 to 153) 3 years: 108 (103 to 113) Absolute change: −41 (−45 to −37); *P*< .001 RYGB (n = 161) Baseline: 151 (146 to 156) 3 years: 109 (104 to 115) Absolute change: −42 (−47 to −38); *P*< .001 SG (n = 67) Baseline: 144 (136 to 152) 3 years: 105 (96 to 113) Absolute change: −38 (−44 to −31); *P*< .001	WEIGHT-RELATED QOL (IWQoL-Kids, mean score) Overall (n = 233) Baseline: 63 (61 to 65) 3 years: 83 (81 to 86) Absolute change: +20.0 (17.4 to 22.7); *P* < .001 Percent change: 42.6% (32.6 to 52.5); *P*< .001 RYGB (n = 159) Baseline: 61.9 (58.9 to 64.8) 3 years: 84.0 (81.1 to 86.9) Absolute change: +22.3 (18.9 to 25.8) Percent change: 50.5% (36.6 to 64.4)	POSTOPERATIVE COMPLICATIONS (≤ 30 days) Major (i.e., life-threatening) Complications Overall: 20 events in 19 of 242 patients (7.9%) - RYGB rate: 9.3% (5.3 to 14.9) - SG rate: 4.5% (0.9 to 12.5) - AGB rate: 7.1% (0.2 to 33.9) Minor Complications Overall: 47 events in 36 of 242 patients (14.9%) - RYGB rate: 16.8% (11.4 to 23.5) - SG rate: 11.9% (5.3 to 22.2) - AGB rate: 7.1% (0.2 to 33.9) LT ADVERSE EVENTS (> 30 days to 3 years) Intra-abdominal Operations

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		AGB (n = 11) Baseline: NR 3 years: NR Absolute change: -10.4 (-26.5, 5.7) % WEIGHT CHANGE, 3 years Overall: −27% (−29 to −25); *P*< .001 RYGB: −28% (−30 to −25); *P*< .001 SG: 26% (−30 to −22); *P*< .001 AGB: -8.3% -19.8, 3.2 MEAN BMI (kg/m2) Overall Baseline: 53 (51 to 54) 3 years: 38 (37 to 40) Absolute change: −15 (−16 to −13) Percent change: −28% (−30 to −25) 5-year median: NR RYGB (n = 161) Baseline: 54 (52 to 55) 3 years: 39 (37 to 41) Absolute change: −15 (−17 to −14) Percent change: −28% (−31 to −25) 5-year median (n = 134): 39.0 (32.0 to 48.2); *P* < .001 SG (n = 67) Baseline: 50 (48 to 52) 3 years: 37 (34 to 39) Absolute change: −13 (−15 to −11) Percent change: −26% (−30 to −22) 5-year median (n = 49): 37.0 (32.1 to 40.8); *P*<	SG (n = 62) Baseline: 63.9 (59.9 to 67.9) 3 years: 82.0 (77.0 to 87.0) Absolute change: +16.3 (12.0 to 20.7) Percent change: 27.8% (19.5 to 36.1) AGB (n = 12) Baseline: 72.3 (67.8 to 81.8) 3 years: 77.4 (62.2 to 92.5) Absolute change: +8.2 (-1.2 to 20.7) Percent change: 11.7% (-3.3 to 26.7)	Overall: 47 events in 30 of 228 patients (13%) - Rate: 22.3 (16.8 to 29.7)/300py RYGB: 38 events in 23 of 161 patients (14%) - Rate: 25.0 (18.2 to 34.4)/300py SG: 9 events in 7 of 67 patients (10%) - Rate: 15.4 (8.0 to 29.5)/300py Endoscopic Procedures Overall: 48 events in 29 of 228 patients (13%) - Rate: 22.8 (17.2 to 30.3)/300py RYGB: 41 events in 24 of 161 patients (15%) - Rate: 27.0 (19.9 to 36.6)/300py SG: 7 events in 5 of 67 patients (7%) - Rate: 12.0 (5.7 to 25.1)/300py NUTRITIONAL ABNORMALITIES Low Vitamin B12 (<145 pg/mL) Overall - Baseline: 1 of 222, < 1% (0–1) - 3 years: 13 of 160, 8% (4–12); *P*= .005 - 5 years: NR RYGB - Baseline: 1 of 159, 1% (0–2) - 3 years: 10 of 121, 8% (3–13); *P*= .01 - 5 years: 14 of 122, 12% (6–17); *P*= .06 SG - Baseline: 0 of 63, 0% - 3 years: 3 of 39, 8% (0–16); *P*= NR - 5 years: 3 of 42, 7% (0–15); *P*= NR

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		.001 AGB (n = 11) Baseline: NR 3 years: NR Absolute change: -3.8 (-9.9 to 2.3) Percent change: -8.1% (-19.9 to 3.6) 5-year median: NR Subgroup: Percent BMI change by age group at 5 years 13–15 years: -22.2% (-26.2% to -18.2%) 16–19 years: -24.6% (-27.7% to -22.5%) *P* = .59 CATEGORICAL BMI CHANGE, 3 years Overall Sample ≥ 40% reduction: 38 of 172 (22%) 30-39% reduction: 40 of 172 (23%) 20-29% reduction: 43 of 172 (25%) > 0-19% reduction: 48 of 172 (28%) Exceeded baseline BMI: 4 of 172 (2%)		Low Vitamin D (< 20.1 ng/mL) Overall - Baseline: 83 of 223, 37% (31–44) - 3 years: 74 of 172, 43% (36–50); *P* = .37 - 5 years: NR RYGB - Baseline: 71 of 159, 45% (37–52) - 3 years: 61 of 128, 48% (39–56); *P* = .64 - 5 years: 61 of 119, 51% (42–60); *P* =.82 SG - Baseline: 12 of 64, 19% (9–28) - 3 years: 13 of 44, 30% (16–43); *P* = .36 - 5 years: 14 of 42, 33% (19–48); *P* = .70 Low Ferritin (female: < 10 µg/L, male: < 20 µg/L) Overall - Baseline: 11 of 225, 5% (2–8) - 3 years: 98 of 171, 57% (50–65); *P* < .001 - 5 years: NR RYGB - Baseline: 4 of 160, 2% (<1–5) - 3 years: 83 of 127, 65% (57–74); *P* < .001 - 5 years: 87 of 122, 71% (63–79); *P* < .001 SG - Baseline: 7 of 65, 11% (3–18) - 3 years: 15 of 44, 34% (20–48); *P* = .01 - 5 years: 19 of 42, 45% (30–60); *P* = .002 Low Vitamin A (< 301 µg/L) Overall - Baseline: 13 of 221, 6% (3–9) - 3 years: 22 of 170, 13% (8–18); *P* = .02 - 5 years: NR

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
				RYGB - Baseline: 9 of 158, 6% (2–9) - 3 years: 20 of 126, 16% (9–24); *P*= .008 - 5 years: 19 of 121, 16% (9–22); *P*= .09?? SG - Baseline: 4 of 63, 6% (<1–12) - 3 years: 2 of 44, 5% (0–11) ; *P*= .93 - 5 years: 3 of 43, 7% (0–15); *P*= .99 Multiple Nutritional Deficiencies (BL vs. 5 years) ≥ 2 deficiencies RYGB: 12% vs. 59%; *P*< .0001 SG: 6% vs. 27%; *P*= .09 ≥ 3 deficiencies RYGB: 3% vs. 19%; *P*= .0005 SG: 2% vs. 2.3%; *P*= NR
Inge, 2017 FABS-5+ High	N = 58 5 to 12 years	BMI (kg/m2) Baseline: 58.5 (55.8 to 61.3) 1 year Mean: 36.0 (33.8 to 38.1) Absolute change: −22.6 (−24.1 to −21.1) Percent change: −38.6% (−40.5 to −36.7) LT follow-up: Mean: 41.5 (38.4 to 44.7) Absolute change: −17.0 (−19.2 to −14.8) Percent change: −29.3% (−33.0 to −25.6) WEIGHT (kg) Baseline: 170.8 (161.1 to 180.6) 1 year Mean: 105.4 (98.2 to 112.7) Absolute change: −65.6 (−70.4 to −60.9) Percent change: −38.4% (−40.3 to −36.5)	NR	NUTRITIONAL DEFICIENCIES at LT follow-up Vitamin B12 Total: 8 of 50 (16.0%) Female: 5 of 35 (14.3%) Male: 3 of 15 (20.0%) Vitamin D Total: 39 of 50 (78.0%) Female: 27 of 35 (77.1%) Male: 12 of 15 (80.0%) Ferritin Total: 32 of 51 (62.8%) Female: 23 of 35 (65.7%) Male: 9 of 16 (56.3%) ADVERSE EVENTS

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		LT follow-up: Mean: 120.9 (111.0 to 130.9) Absolute change: −50.0 (−56.8 to −43.1) Percent change: −29.5% (−33.2 to −25.7)		Obstetric - 17 (45.9%); Event rate: 85.9 (58.0 to 127.1) Gynecologic - 7 (18.9%); Event rate: 68.7 (44.3 to 106.5) Upper Endoscopy - 13 (22.4%); Event rate: 62.4 (43.3 to 89.7) Cholecystectomy - 12 (20.7%); Event rate: 25.8 (14.7 to 45.4) Excess skin removal - 8 (13.8%); Event rate: 23.7 (13.1 to 42.7) Blood transfusion - 2 (3.4%); Event rate: 6.5 (2.1 to 20.0) Colonoscopy - 2 (3.4%); Event rate: 6.5 (2.1 to 20.0) Parenteral infusion for micronutrient deficiency - 2 (3.4%); Event rate: 6.5 (2.1 to 20.0) Repair GI perforation - 3 (5.2%); Event rate: 6.5 (2.1 to 20.0) Appendectomy - 2 (3.4%); Event rate: 4.3 (1.1 to 17.2) Exploratory laparoscopy/laparotomy - 2 (3.4%); Event rate: 4.3 (1.1 to 17.2)

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
				*Event rate = # of events per 1000 person-years (i.e., 100 subjects followed for 10 years).
Olbers, 2012 AMOS Moderate	N = 161 5 years	BMI OUTCOMES Mean BMI (kg/m^2) Baseline - RYGB: 45·5 (6·1), MT: 42·2 (5) 5 years - RYGB: 32.3 (6.3), MT: 44.6 (9.5) Within group: RYGB: MD, −13.1 (−14.5 to −11.8); *P* < .001 MT: +3.3 (+1.1 to +4.8); *P* value NR Between group: MD, −12.26 (−15.2 to − 9.3); *P* < .001 BMI < 35 kg/m^2 at 5 years RYGB: 72% MT: 7% BMI < 30 kg/m^2 at 5 years RYGB: 37% MT: 3% BODY WEIGHT OUTCOMES Mean body weight (kg) Baseline - RYGB: 133 (22), MT: 124 (21) 5 years - RYGB: 96.0 (22.2), MT: 133.3 (28.9) Within group (RYGB): MD, −36·8 (−40·9 to −32·8); *P* < .001 Between group: MD, −37.21 (−46.4 to − 28.0); *P* < .001 Weight loss at 5 years by % category ≥ 20% total body weight loss RYGB: 70% MT: 2%	WEIGHT-SPECIFIC QOL (OP-14 scale) Baseline - RYGB: 49·1 (26·4) 5 years - RYGB: 37·4 (28·8), MT: 45·1 (34·9) Within group (RYGB): MD, -13·0 (-19·6 to -6·4); *P* < .001* Between group: MD, -7·9 (-20·7 to 4·5); *P* = .22 GENERIC QOL (SF-36 scores) Physical Functioning Baseline - RYGB: 72·1 (22·4) 5 years - RYGB: 84·4 (21·2), MT: 75·9 (23·4) Within group (RYGB): MD, 13·5 (8·1 to 19·0); *P* < .001* Between group: MD, 8·8 (0·0 to 17·6); *P* = .05* Physical Role Functioning Baseline - RYGB: 75·9 (24·6) 5 years - RYGB: 83·9 (25·2), MT: 71·3 (30·9) Within group (RYGB): MD, 11·2 (4·0 to 18·3); *P* = .002* Between group: MD, 13·5 (2·2 to 24·8); *P* = .02* General Health Perceptions Baseline - RYGB: 53·8 (23·4) 5 years - RYGB: 64·8 (22·7), MT: 56·2 (26·6) Within group (RYGB): MD, 12·4 (6·5 to 18·3); *P* < .001* Between group: MD, 8·7 (-1·1 to 18·5); *P* = .08 Physical Component Score Baseline - RYGB: 44·1 (9·5)	NUTRITIONAL DEFICIENCIES Vitamin D Insufficiency (< 50 nmol/L) Baseline - RYGB: 16 of 33 (49%); MT: not reported 5 years - RYGB: 46 of 73 (63%), MT: 20 of 35 (57%); *P* = .67 Vitamin D Deficiency (< 30 nmol/L) Baseline - RYGB: 4 of 33 (12%), MT: not reported 5 years - RYGB: 20 of 73 (27%), MT: 7 of 35 (20%); *P* = .48 Low Vitamin B12 (<145 pmol/L) Baseline - RYGB: 1 of 74 (1%), MT: not reported 5 years - RYGB: 16 of 73 (66%), MT: 2 of 31 (6%); *P* = .05 Low Ferritin (< 45 pmol/L (boys); < 22·5 pmol/L (girls)/Iron (< 9 µmol/L) Levels Baseline - RYGB: 18 of 76 (24%), MT: not reported 5 years - RYGB: 51 of 77 (66%), MT: 12 of 42 (29%); *P* < .001 Anemia (females: Hg < 120 g/dL; males: Hg < 130 g/dL) Baseline - RYGB: 8 of 78 (10%), MT: not reported 5 years - RYGB: 25 of 77 (32%), MT: 3 of 42 (7%); *P* = .001

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	WEIGHT CHANGE	QUALITY OF LIFE	HARMS
		10 to 19% total weight loss RYGB: 18% MT: 8% 0 to 9% total weight loss RYGB: 10% MT: 21% Weight gain RYGB: 2% MT: 69%	5 years - RYGB: 48·3 (10·3), MT: 45·7 (10·0) Within group (RYGB): MD, 5·2 (2·5 to 7·9); *P* < .001 Between group: MD, -2·9 (-6·9 to 1·0); *P*= .14 No Significant Differences (within- or between-group) - Bodily pain - Vitality - Mental health - Social role functioning - Emotional role functioning - Mental component score	ADVERSE EVENTS (RYGB adolescents only) Serious Adverse Events (events involving hospitalization) - Any surgery: 20 of 81 (21 procedures; 25%) - Laparoscopy (bowel obstruction): 11 of 81 (14%) - Cholecystectomy (gall stones): 9 of 81 (11%) - Laparotomy (abdominal pain): 1 of 81 (1%) - Blood transfusion (severe anemia): 2 of 81 (2%) - Overnight observation (abdominal pain): 9 of 81 (11%) - Psychiatric assessment (drug abuse): 6 of 81 (7%) - NO DEATHS OCCURRED Other Adverse Events (not requiring hospitalization) - Anemia: 25 of 77 (32%) - Low vitamin D: 2 of 73 (3%) - Low vitamin B12: 16 of 73 (22%) - Low ferritin or iron: 51 of 77 (66%) - Assessment for eating disorder: 1 of 81 (1%)

Abbreviations. AGB: adjustable gastric banding; AMOS: Adolescent Morbid Obesity Surgery, BL: baseline; BMI: body mass index; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; kg: kilograms; kg/m^2: kilograms per meters squared; LT: long term; MD: mean difference; MT: medical therapy; nmol/L: nanomoles per liter; OP-14 Scale: Obesity-related Problems 14 Scale; QoL: quality of life; RYGB: Roux-en-Y gastric bypass; SF-36: short form-36 survey; SG: sleeve gastrectomy; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth.

Table D10. Outcomes in Adolescent Studies: T2DM, Hypertension, Coronary Artery Disease, Joint Arthropathy

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE	JOINT ARTHROPATHY
Inge, 2018 Teen-LABS/TODAY High	N = 93 2 years	HbA1c (%) Teen-LABS - BL: 6.8, 2yr: 5.5; MD, −1.3 (−2.2 to −0.5) TODAY - BL: 6.4, 2yr: 7.8; MD, +1.4 (0.9 to 1.9) *P* < .001 HbA1c RANGE Normal (< 5.7%) Teen-LABS - BL: 10 of 30 (34%) , 2yr: 15 of 30 (74%) TODAY - BL: 17 of 63 (28%), 2yr: 7 of 63 (13%) Normal to Prediabetes (< 6.5%) Teen-LABS - 2yr: 19 of 30 (94%) TODAY - 2yr: 20 of 63 (38%) *P* = .003 Diabetes (≥ 6.5%) Teen-LABS - NR TODAY - BL: 23 of 63 (35%), 2yr: 34 of 63 (62%) FASTING PLASMA GLUCOSE (mg/dL) Teen-LABS - BL: 125.1, 2yr: 89.3; MD, −35.8 (−53.9 to −17.7) TODAY - BL: 119.2, 2yr: 151.8; MD, +32.6 (21.1 to 44.2) *P* < .001	SYSTOLIC BP (mmHg) Teen-LABS - BL: 122.9, 2yr: 122.0; MD, −0.8 (−6.3 to 4.7) TODAY - BL: 119.3, 2yr: 120.8; MD, +1.5 (−1.4 to 4.5) DIASTOLIC BP (mmHg) Teen-LABS - BL: 75.4, 2yr: 73.3; MD, −2.1 (−6.2 to 2.0) TODAY - BL: 71.3, 2yr: 71.4; MD, +0.1 (−2.6 to 2.8) ELEVATED BP[a] Teen-LABS - BL: 20 of 30; 66.7% (45.3 to 82.9) - 2yr: 5 of 30; 18.6% (6.8 to 41.6) TODAY - BL: 13 of 63; 20.6% (11.6 to 34.1), - 2yr: 23 of 63; 41.9% (27.7 to 57.6)	LDL-C LEVEL (mg/dL) Teen-LABS - BL: 92.0, 2yr: 85.2; MD, −6.8 (−22.2 to 3.9) TODAY - BL: 89.0, 2yr: 82.8; MD, −6.2 (−15.4 to 2.9) TRIGLYCERIDES (mg/dL) Teen-LABS - BL: 108.8, 2yr: 88.1; MD, −20.7 (−24.4 to −17.4) TODAY - BL: 100.7, 2yr: 116.1; MD, +15.4 (10.4 to 21.8)	NR
Inge, 2014 Teen-LABS Moderate	N = 242 3 years	T2DM REMISSION[b], 3 years Observed remission Total: 19 of 20; 95% (85 to 100)	ELEVATED BP REMISSION[d] 3 years Observed remission	NR	REPORTED MUSCULOSKELETAL PAIN DURING OR AFTER

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE	JOINT ARTHROPATHY
		RYGB: 17 of 18; 94% (84 to 100) SG: 2 of 2; 100% (100 to 100) Modeled remission rate Total: 90% (65 to 98) RYGB: 94% (66 to 99) SG: 68% (7 to 99) Subgroup analysis: T2DM remission by age group Baseline prev of T2DM 13–15 years: 7 (11%) 16–19 years: 22 (14%) 5-year remission 13–15 years: 6 (83%) 16–19 years: 15 (87%) RR, 0.86 (95% CI, 0.74 to 0.99); *P*= .046 PREDIABETES REMISSION[c], 3 years Observed remission Total: 13 of 17; 76% (56 to 97) RYGB: 11 of 15; 74% (51 to 96) SG: 2 of 2; 100% (100 to 100) Modeled remission rate Total: 77% (48 to 92) RYGB: 94% (66 to 99) SG: not estimable	Total: 56 of 76; 74% (64 to 84) RYGB: 47 of 60; 78% (68 to 89) SG: 9 of 16; 56% (32 to 81) Modeled remission rate Total: 73% (60 to 83) RYGB: 78% (64 to 88) SG: 53% (27 to 78) Subgroup analysis: HTN remission by age group Baseline prev of HTN 13–15 years: 18 of 66 (29%) 16–19 years: 59 of 162 (37%) 5-year remission 13–15 years: 77% (57.1% to 100.0%) 16–19 years: 67% (54.5% to 81.5%) - After adjustment, postoperative HTN remission was similar by age group (*P*= .84)		400 meter WALK TEST (vs. baseline) Baseline: 25% 1 year: 8%; RR: 0.62 (95% CI, 0.51-0.71); *P*< .01 2 years: 12%; RR: 0.47 (95% CI, 0.37-0.62); *P*< .01
Inge, 2017 FABS-5+ High	N = 58 5 to 12 years	DIABETES Baseline: 9 of 56 (16.1%) LT Follow-up: 1 of 55 (1.8%) Remission[e]: 7 of 8 (87.5%) Incidence[f]: 0 of 45 (0%) HBA1C (%)	Baseline: 27 of 57 (47.4%) LT Follow-up: 9 of 55 (16.4%) Remission[e]: 19 of 25 (76.0%) Incidence[f]: 3 of 29 (10.3%)	LDL-C LEVEL (mmol/L) Baseline: 2.78 (2.59 to 2.97) LT Follow-up: 2.44 (2.22 to 2.67) TRIGLYCERIDES (mmol/L) Baseline: 1.45 (1.27 to 1.66) LT Follow-up: 0.99 (0.86 to 1.13)	NR

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE	JOINT ARTHROPATHY
		Baseline: 5.3 (5.1 to 5.6) LT Follow-up: 5.2 (4.9 to 5.6) FPG (mmol/L) Baseline: 5.37 (5.11 to 5.65) LT Follow-up: 4.75 (4.17 to 5.34)			
Olbers, 2012 AMOS Moderate	N = 161 5 years	T2DM + RESOLUTION (FPG ≥ 7 mmol/L or HbA1c ≥ 45 mmol/mol) Baseline - RYGB: 3 of 81 (3.7%) 5 years - RYGB: 0 of 79 (0%) , MT: 1 of 44 (2.3%); *P*= .72 Resolution (RYGB only): 3 of 3 (100%); *P*= .25 HBA1C OUTCOMES Mean HbA1c (mmol/mol) Baseline - RYGB: 35·1 (3·9) 5 years - RYGB: 33·5 (3·8), MT: 35·3 (10·6) Within group: MD, −1·56 (−2·5 to −0·6); *P*= .002 Between group: MD, −1·8 (−5·4 to +1·8); *P*= .32 Elevated HbA1c (≥ 39 mmol/mol) Baseline - RYGB: 10 of 80 (12.5%) 5 years - RYGB: 6 of 65 (9.2%), MT: 6 of 37 (16.2%); *P*= .35 Resolution (RYGB only): 5 of 8 (62.5%)*; *P*=.73 FPG OUTCOMES Mean FPG (mmol/L) Baseline - RYGB: 5·1 (0·5)	ELEVATED BP (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg) Baseline - RYGB: 12 of 78 (15.4%) 5 years - RYGB: 2 of 72 (2.8%), MT: 4 of 39 (10.3%); *P*= .18 Resolution (RYGB only): 12 of 12 (100%); *P*= .01 SYSTOLIC BP Mean SBP (mmHg) Baseline - RYGB: 124·6 (12.3) 5 years - RYGB: 113.2 (10·7), MT: 121.4 (11·4) Within group: MD, −11·55 (−14·0 to −9·1); *P*< .001 Between group: MD, −8·18 (−12·5 to −3·8); *P*< .001 Elevated SBP (≥ 140 mmHg) Baseline - RYGB: 11 of 78 (14.1%) 5 years - RYGB: 0 of 72 (0%), MT: 2 of 39 (5.1%); *P*= .12 Resolution (RYGB only): 11 of 11 (100%); *P*= .001 DIASTOLIC BP Mean DBP (mmHg) Baseline - RYGB: 76·9 (9·8)	LDL-C Mean LDL-C (mmol/L) Baseline - RYGB: 2·6 (0·7) 5 years - RYGB: 2·2 (0·7), MT: 3 (0·8) Within group: MD, −0·46 (−0·6 to −0·3); *P*< .001 Between group: MD, −0·88 (−1·2 to −0·6); *P*< .001 Elevated LDL-C (≥ 3·37 mmol/L) Baseline - RYGB: 13 of 81 (16%) 5 years - RYGB: 0 of 76 (0%), MT: 9 of 41 (22%); *P*< .001 Resolution (RYGB only): 13 of 13 (100%); *P*< .001 TRIGLYCERIDES Mean Triglycerides (mmol/L) Baseline - RYGB: 1·3 (0·6) 5 years - RYGB: 0·9 (0·3), MT: 1·4 (0·8) Within group: MD, −0·39 (−0·5 to −0·3); *P*< .001 Between group: MD, −0·47 (−0·7 to −0·2); *P*< .001 Elevated Triglycerides (≥ 1·47 mmol/L) Baseline - RYGB: 25 of 80 (31%) 5 years - RYGB: 0 of 76 (0%), MT: 10 of	

AUTHOR, YEAR STUDY NAME RISK OF BIAS	TOTAL N FOLLOW-UP	T2DM	HYPERTENSION	CORONARY ARTERY DISEASE	JOINT ARTHROPATHY
		5 years - RYGB: 4·8 (0·4), MT: 5·2 (0·7) Within group (RYGB): MD, −0·33 (−0·5 to −0·1); *P*= .001 Between group: MD, −0·45 (−0·8 to −0·1); *P*= .009 Impaired FPG (≥ 5.6 mmol/L) Baseline - RYGB: 16 of 80 (20%) 5 years - RYGB: 0 of 36 (0%), MT: 2 of 18 (11.1%); *P*=.11 Resolution (RYGB only): 13 of 13 (100%)*; *P*= .003	5 years - RYGB: 69·4 (9·9), MT: 77·7 (10·0) Within group: MD, −7·4 (−10·2 to −4·6); *P* < .001 Between group: MD, −8·28 (−12·2 to −4·4); *P*< .001 Elevated DBP (≥ 90 mmHg) Baseline - RYGB: 4 of 78 (5.1%) 5 years - RYGB: 2 of 72 (2.8%), MT: 4 of 39 (10.3%); *P*= .18 Resolution (RYGB only): 4 of 4 (100%); *P* =.69	41 (24%); *P*< .001 Resolution (RYGB only): 22 of 22 (100%)*; *P*< .001	

Notes. [a] Use of BP-lowering medications or SBP ≥ 95th percentile or DBP ≥ 95th percentile (for age, sex, height) if < 18 years of age; or if ≥ 18 years, SBP >140 mmHg or DBP > 90 mmHg. Remission of elevated BP required the absence of BP-lowering medications, and SBP and DBP in the normal range for age. [b] Remission of DM was defined as no use of medication for DM, and HbA1c < 6.5%, or, if HbA1c was not available, FBG < 126 mg/dL. [c] Remission of Pre-DM was defined as HbA1c < 5.7%, or, if HbA1c was not available, FBG < 100 mg/dL. [d] If < 18 years of age, use of BP medications or SBP ≥ 95th percentile or DBP ≥ 95th percentile (for age, sex, height); or if ≥ 18 years, SBP > 140 mmHg or DBP > 90 mmHg. [e] Remission was calculated as the number of participants (with sufficient data to define comorbidity state) who do not have the condition at long-term visit divided by the number of participants who had the condition at baseline. [f] Incidence was calculated as the number of participants (with sufficient data to define comorbidity state) who have the condition at long-term visit divided by the number of participants who did not have the condition at baseline.
Abbreviations. AMOS: Adolescent Morbid Obesity Surgery; BP: blood pressure; CI: confidence interval; DBP: diastolic blood pressure; FABS-5+: Follow-up of Adolescent Bariatric Surgery at 5 Plus years; FPG: fasting plasma glucose; HbA1c: glycated hemoglobin; HTN: hypertension; LDL-C: low density lipoprotein cholesterol; LT: long term; MD, mean difference; mmHg: millimeters of mercury; mmol/L: millimoles per liter; MT: medical therapy; NR: not reported; RR: relative risk; RYGB: Roux-en-Y gastric bypass; SBP: systolic blood pressure; SG: sleeve gastrectomy; T2DM: type 2 diabetes; Teen-LABS: Teen–Longitudinal Assessment of Bariatric Surgery; TODAY: Treatment Options of Type 2 Diabetes in Adolescents and Youth; yr: year.

APPENDIX E. APPLICABLE CODES

CODES	DESCRIPTION	
CPT		**Known as**
43633	Gastrectomy, partial, distal; with Roux-en-Y reconstruction	Roux-en-Y gastric bypass
43644	Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and Roux-en-Y gastroenterostomy (roux limb 150 cm or less)	Roux-en-Y gastric bypass
43645	Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and small intestine reconstruction to limit absorption	Roux-en-Y gastric bypass
43659	Unlisted laparoscopy procedure, stomach	Various procedures
43770	Laparoscopy, surgical, gastric restrictive procedure; placement of adjustable gastric restrictive device (e.g., gastric band and subcutaneous port components)	Adjustable gastric banding
43771	Laparoscopy, surgical, gastric restrictive procedure; revision of adjustable gastric restrictive device component only	Adjustable gastric banding revision
43772	Laparoscopy, surgical, gastric restrictive procedure; removal of adjustable gastric restrictive device component only	Adjustable gastric banding removal
43773	Laparoscopy, surgical, gastric restrictive procedure; removal and replacement of adjustable gastric restrictive device component only	Adjustable gastric banding removal and replacement
43774	Laparoscopy, surgical, gastric restrictive procedure; removal of adjustable gastric restrictive device and subcutaneous port components	Adjustable gastric banding removal
43775	Laparoscopy, surgical, gastric restrictive procedure; longitudinal gastrectomy (i.e., sleeve gastrectomy)	Sleeve gastrectomy
43842	Gastric restrictive procedure, without gastric bypass, for morbid obesity; vertical-banded gastroplasty	Vertical banded gastroplasty
43843	Gastric restrictive procedure, without gastric bypass, for morbid obesity; other than vertical-banded gastroplasty	Adjustable banded gastroplasty
43845	Gastric restrictive procedure with partial gastrectomy, pylorus-preserving duodenoileostomy and ileoileostomy (50 to 100 cm common channel) to limit absorption (biliopancreatic diversion with duodenal switch)	Biliopancreatic diversion with duodenal switch
43846	Gastric restrictive procedure, with gastric bypass for morbid obesity; with short limb (150 cm or less) Roux-en-Y gastroenterostomy	Roux-en-Y gastric bypass
43847	Gastric restrictive procedure, with gastric bypass for morbid obesity; with small intestine reconstruction to limit absorption	Roux-en-Y gastric bypass
43848	Revision, open, of gastric restrictive procedure for morbid obesity, other than adjustable gastric restrictive device (separate procedure)	
43860	Revision of gastrojejunal anastomosis (gastrojejunostomy) with reconstruction with or without partial gastrectomy or intestine resection; without vagotomy	
43865	Revision of gastrojejunal anastomosis (gastrojejunostomy) with reconstruction with or without partial gastrectomy or intestine resection; with vagotomy	
43999	Unlisted procedure, stomach	
HCPCS		
S2083	Adjustment of gastric band diameter via subcutaneous port by injection or aspiration of saline	Adjustable gastric banding

CODES	DESCRIPTION	
S2085	Laparoscopy, gastric restrictive procedure, with gastric bypass for morbid obesity, with short limb (less than 100 cm) Roux-en-Y gastroenterostomy	Roux-en-Y gastric bypass
ICD-10-CM		
E66.01	Morbid (severe) obesity due to excess calories	
E66.09	Other obesity due to excess calories	
E66.1	Drug-induced obesity	
E66.2	Morbid (severe) obesity with alveolar hypoventilation	
E66.8	Other obesity	
E66.9	Obesity, unspecified	
Z46.51	Encounter for fitting and adjustment of gastric lap band	
Z68.30	Body mass index [BMI] 30.0-30.9, adult	
Z68.31	Body mass index [BMI] 31.0-31.9, adult	
Z68.32	Body mass index [BMI] 32.0-32.9, adult	
Z68.33	Body mass index [BMI] 33.0-33.9, adult	
Z68.34	Body mass index [BMI] 34.0-34.9, adult	
Z68.35	Body mass index [BMI] 35.0-35.9, adult	
Z68.36	Body mass index [BMI] 36.0-36.9, adult	
Z68.37	Body mass index [BMI] 37.0-37.9, adult	
Z68.38	Body mass index [BMI] 38.0-38.9, adult	
Z68.39	Body mass index [BMI] 39.0-39.9, adult	
Z68.41	Body mass index [BMI] 40.0-44.9, adult	
Z68.42	Body mass index [BMI] 45.0-49.9, adult	
Z68.43	Body mass index [BMI] 50.0-59.9, adult	
Z68.44	Body mass index [BMI] 60.0-69.9, adult	
Z68.45	Body mass index [BMI] 70 or greater, adult	
Z68.53	Body mass index [BMI] pediatric, 85th percentile to less than 95th percentile for age	
Z68.54	Body mass index [BMI] pediatric, greater than or equal to 95th percentile for age	

Note: Inclusion on this list does not guarantee coverage.