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ORIGINAL CONTRIBUTIONS

# Bariatric Surgery Coverage: a Comprehensive Budget Impact Analysis from a Payer Perspective

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**Abstract**

**Objective** The objective of this study was to estimate a payer's budget impact of bariatric surgery coverage under (1) unrestricted, (2) budget-restricted ($500,000/year), and (3) quantity-restricted (100/year) medical benefit plan scenarios versus non-coverage in general and type 2 diabetes mellitus (T2DM) populations over a 10-year period.

**Methods** Using recently published literature and health technology assessment reports, the model evaluated a hypothetical payer population of 100,000 members under current real-world trends: BMI-defined obesity groups (31.3% normal/underweight, 33% overweight, 20.4% obese, 9% severely obese and 6.3% morbidly obese), T2DM prevalence (6.7–27.5%; 100% for the T2DM model), surgery type (LAGB, BPD/DS, VSG, and RYGB), and differential outcomes (T2DM resolution, costs, and reoperation and complications rates). Assuming a surgery election rate of 1.42% among eligible candidates with a 3% discount rate and 10% annual surgery turnover rate, the model calculated the incremental cost per-member-per-month (PMPM) by estimating the difference in total non-T2DM and T2DM-related expected costs and savings. One-way (± 25%) sensitivity analysis was performed.

**Results** The impact of covering bariatric surgery under multiple scenarios for a general (or T2DM) population ranged from an additional $0.3 to $3.6 (T2DM: $0.3 to $10.5) PMPM in year 1. Incremental costs diminished over time, breaking even between years 5 and 9 (T2DM: 5–6), and by year 10, cost savings were estimated to be between $1.5 and $4.8 (T2DM: $1.2 and $31.8).

**Conclusion** Providing bariatric surgery coverage may have a modest short-term budget impact increase but would lead to long-term net cost savings in a general population model. The cost savings were much more pronounced in the T2DM model.

**Keywords** Bariatric surgery · Obesity · Costs · Affordability · Efficiency · Payer · Access · Insurance

## Introduction

According to the most recent US National Health and Nutrition Examination Survey, more than 7 out of 10 Americans are either overweight or obese [1]. This is troublesome because, while the prevalence of overweight people increased by 25.7% in the past two decades, the obese group grew by a disproportionately high rate of 65.1%. The latter is alarming given the association between obesity and many chronic conditions, including type 2 diabetes mellitus (T2DM), cardiovascular heart disease, cancer (endometrium, breast, colon), musculoskeletal disorders, sleep apnea, depression, and gallbladder disease [2]. The magnitude of this problem is illustrated by the statistic that obesity was directly and indirectly accountable for 9.1% of total US annual medical expenditures, amounting to as much as $153.6 billion (2017 dollars) [3]. In contrast to medical or

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lifestyle intervention, bariatric surgery has been shown to be the only treatment to provide significant and long-term weight loss [4–8], reduce chronic conditions including T2DM [4–9], hypertriglyceridemia [5, 6, 8, 9], hypertension [6, 7, 9], dyslipidemia [6, 9], and sleep apnea [6], and improve survival [10, 11], quality of life [12], and occupational outcomes (e.g., productivity) [13].

In addition to these clinical data, economic studies on bariatric procedures find that bariatric surgery meets commonly accepted thresholds for cost-effectiveness and willingness-to-pay across multiple BMI categories, time horizons (2 years to lifetime), and procedure types, with the results remaining robust under extreme model assumptions [14]. Nevertheless, just 196,000 bariatric surgery procedures were performed in 2015 in the United States (USA) [15], a number that appears quite low given the ever-increasing obesity population. While there could be a number of issues at play, Gulliford et al. suggest that the unmet gap is a plausible symptom of access issues wherein payers and healthcare systems perceive obesity as a lifestyle choice making it difficult to justify any resources required to offer bariatric surgery more freely [16].

At a time when healthcare dollars are being intensely scrutinized so that they can be put to optimal use, while simultaneously constraining healthcare spending, questions on the budget impact (BI) of bariatric surgery need to be addressed. In addition, understanding the dynamics of offering coverage under different medical plan scenarios and its impact on a health plan's overall budget is also critical, so that the most efficient option(s) may be identified. Therefore, the purpose of the current study is to estimate the short- and long-term BI of covering bariatric surgery in (1) unrestricted, (2) budget-restricted, and (3) quantity-restricted medical benefit plan scenarios for severely and morbidly obese individuals compared to standard of care (nonsurgical management) from a US health plan payer perspective in a general and T2DM-only population over a 10-year period.

## Data and Methods

An Excel 2010-based (Microsoft Office, USA) decision-analytic BI model was constructed for a hypothetical population of 100,000 individuals. The model evaluated the financial impact to a health plan over a 10-year period by offering bariatric surgery medical benefit plan coverage to surgery-eligible members who may or may not elect to receive the surgery under one of the following three scenarios: (1) unrestricted access, (2) up to $500,000 per year spent towards performing bariatric surgery and treating complications (budget-restricted), and (3) up to 100 surgeries performed on an annual basis (quantity restricted). Each of these three scenarios was compared against the standard nonsurgical weight management approach. The model assumed that members with BMI ≥ 35 were eligible for bariatric surgery with approximately 1.42% of all eligible candidates electing to receive the surgery [17]. As for the bariatric surgery coverage options with restrictions, a hierarchy was enforced based upon efficiency considerations, prioritizing patients for surgery by disease severity, i.e., morbidly obese with T2DM received priority over severely obese with T2DM, followed by non-T2DM morbidly obese and the non-T2DM severely obese individuals. If surgery-eligible members exceeded the number of surgeries that can be performed in a calendar year, they would be rolled over to the following year.

All members were categorized using the widely accepted BMI-based obesity thresholds: normal/underweight (BMI < 25 kg/m$^2$), overweight (BMI 25–29.9 kg/m$^2$), obese (BMI 30–34.9 kg/m$^2$), severely obese (BMI 35–39.9 kg/m$^2$), and morbidly obese (BMI ≥ 40 kg/m$^2$). One third of the overall model population were normal/underweight, another third overweight, while the remaining were obese (20.4% obese, 9% severely obese, and 6.3% morbidly obese) [18]. Table 1 The obese cohort (BMI ≥ 30 kg/m$^2$) was presumed to grow at an annual rate of 0.13% in line with the current almost plateaued obesity rates [18–20]. Based on findings by Bays et al., T2DM prevalence across the above BMI categories was expected to vary between 6.7 and 27.5%, with the disease prevalence increasing as the BMI increases [21]. T2DM prevalence was also hypothesized to increase at an annual rate of 0.7% in each of the BMI groups [22]. The model accounted for the current utilization of the four prevalent surgical techniques—band/laparoscopic adjustable gastric banding (LAGB), biliopancreatic bypass w/ duodenal switch (BPD/DS), sleeve/vertical sleeve gastrectomy (VSG), and Roux-en-Y gastric bypass (RYGB) with VSG being the most frequent procedure (6 out of 10 cases) [15]. The model also incorporated each surgery type's associated costs ($15,987 to $36,160) and their respective rates of complications (9.5 to 24.5%), reoperation (2.0 to 14.9%) [14], and T2DM resolution (47.9 to 95.0%) [23–26]. Mean complication costs were included for the severe and morbidly obese surgery patients. We assumed an annual turnover rate of 10%, i.e., members undergoing surgery and subsequently leaving the plan, so that their future cost savings from the surgery would be lost to the insurance provider from the time they exit the model. Given the model's steady-state assumption, their exit would be balanced by the entry of surgery-eligible individuals consistent with the prevalence of these groups.

### Costs

Cawley et al. reported the average annual medical expenditures for any given patient, and the incremental regression-adjusted costs associated at multiple BMI levels stratified by diabetes status (yes/no) using the 2000–2010 Medical Expenditure Panel Survey data [27]. We assumed that the expenditures equated to costs from the payer's perspective and calculated the average for each of the BMI categories. We further adjusted the costs to 2016 US dollars using the Bureau of Labor Statistics' US Medical Care inflation factor [28]. For instance, the annual cost borne by a payer for an overweight member without T2DM would be the sum of the baseline annual cost ($2072) and the additional cost for an individual with BMI between 25 and 29.9 kg/m$^2$ but no diabetes, i.e., $518 (Table 1). In case of a T2DM patient, an additional $806 would be added to calculate the patient's annual cost to the payer. The model also assumed that annual costs for the surgery-eligible groups grew at a rate of 7.5% per annum compared to 5% for the rest of the cohort [29], thereby underscoring the cost burden of this subgroup of patients. Given the long duration of the study, a 3% discount rate was applied to ascertain costs in present value terms.

Cost savings following surgery were calculated based on the findings from an observational pre-post administrative claims analysis of RYGB patients by Mullen and Marr [31]. They found that the plan's actual paid costs for the RYGB cohort was lower than their projected trend costs (based on preoperative amounts) from the first post-surgery year. We calculated the proportion of savings for each of the five post-operative years reported as follows:

$$1-[\text{Actual plan paid costs} \div \text{Projected trend paid amount}]$$

On this basis, we calculated that general non-T2DM healthcare savings for post-operative years 1–5 (discarding the year of surgery) as 40, 45, 60, 68, and 59%, respectively. The slight decrease in the postoperative years 4 to 5 savings occurred because of hospital admissions for conditions (e.g., pregnancy) and treatments (e.g., joint replacement, sports-related injuries) from lifestyle changes that resulted from the reduced physiologic burden of obesity. Data paucity beyond post-operative year 5 led us to apply a constant 59% saving rate to the remaining years in the study. As for T2DM savings, evidence suggests that T2DM resolution can be observed as early as within a month of surgery receipt [32]. Therefore, the model splits the annual T2DM costs evenly into the cost and saving buckets for the surgical year, before classifying them as savings for the subsequent post-operative years.

### Outcomes

The outputs from this BI model included the total number of surgeries performed and their corresponding costs, non-T2DM general healthcare, and T2DM-specific savings, as well as annual and 10-year cumulative impacts. We also reported the earliest year where the annual cost savings exceeded the costs (inflection point). The breakeven point for any given coverage was the earliest point at which its cumulative savings exceeded the cumulative costs leading to net benefits. Net healthcare costs were estimated by calculating the difference in total projected healthcare cost (inclusive of surgery cost) from the general or the T2DM-related savings. For each coverage scenario, the annual per-member-per-month cost (PMPM) was defined as the ratio of the net healthcare costs and the member population. We then compared each of the coverage scenarios with the nonsurgical approach by calculating the incremental cost PMPM over a 10-year period.

### T2DM Model

For the T2DM model, parameters were obtained from T2DM-specific populations where available. These included the distribution of BMI categories of the T2DM population and the prevalence of the four surgical types. All model parameters are tabulated in Table 1.

### Sensitivity Analysis

To gauge the robustness of the results and to assess the impact of individual parameters, a one-way sensitivity analysis was conducted by varying each model parameter by ± 25% of its default value. The results were presented using a Tornado diagram.

## Results

### General Model

#### No Surgery Coverage

For a health plan with 100,000 members, total healthcare costs were projected to increase from $381.9 to $495.6 million over the next 10 years without bariatric surgery (Table 2). Of these, the general non-T2DM healthcare portion of the net costs increased from $355.4 to $456.9 million. Approximately 7–8% of the net healthcare costs were attributable to T2DM. During this period, the cost burden of the surgery-eligible group increased from 34.7 to 40%, while their actual numbers in the model increased by only 0.2% (i.e., from 15.3 to 15.5%).

#### Unrestricted Coverage

With unrestricted access, roughly 2186 surgeries would be performed during the 10-year period at a cost of $45.8 million (undiscounted), leading to cumulative undiscounted general non-T2DM and T2DM cost savings of $43.1 and $12.9 million, respectively. There would also be a resolution of 401 T2DM cases. A cumulative impact of − $7.8 million (e.g., cost savings) was estimated (Table 3; Fig. 1). Compared to the nonsurgical approach, the incremental cost PMPM shifted from + $3.6 to − $4.8. Overall cost savings first occurred during year 5.

**Table 1** Best evidence literature review summary

| General population model parameters | Base case | References |
|---|---|---|
| Population size | 100,000 | Study assumption |
| Expected growth in population | 0.0% | |
| Max. annual cost dollars towards bariatric surgery | $500,000 | |
| Max. number of bariatric surgeries permitted per year | 100 | |
| Proportion of lost surgery members | 10.00% | |
| Unrestricted bariatric surgeries per 1000 | 14.20 | [17] |
| Demographics | | |
| BMI prevalence in year 1 | | [18] |
| Normal | 31.30% | |
| Overweight | 33.00% | |
| Obese | 20.40% | |
| Severely obese | 9.00% | |
| Morbidly obese | 6.30% | |
| Proportion of BMI w/ T2DM | | [21] |
| Normal | 6.70% | |
| Overweight | 17.00% | |
| Obese | 13.50% | |
| Severely obese | 17.00% | |
| Morbidly obese | 27.50% | |
| BMI prevalence average growth rate | | [18–20] |
| Overweight | −0.10% | |
| Obese/clinically severe/morbidly obese | 0.13% | |
| Annual growth rate of BMI w/ T2DM | 0.66% | [22] |
| Costs | | |
| Health plan's average per-member-per-year (PMPY) | $2072 | [27] |
| Annualized BMI-specific non-T2DM general add-on costs | | [27] |
| Normal | $230 | |
| Overweight | $518 | |
| Obese | $1956 | |
| Severely obese | $4546 | |
| Morbidly obese | $6848 | |
| Annualized BMI-specific T2DM-related add-on costs | | [27] |
| Normal | $230 | |
| Overweight | $806 | |
| Obese | $1726 | |
| Severely obese | $3740 | |
| Morbidly obese | $6330 | |
| Annual healthcare cost increase | | [29] |
| Norma /overweight/obese | 5.0% | |
| Severely/morbidly obese | 7.5% | |
| Surgery | | |
| Surgery prevalence | | [15] |
| LAGB | 10.75% | |
| BPD/DS | 0.45% | |
| VSG | 58.48% | |
| RYGB | 30.32% | |
| Surgery costs | | [14] |
| LAGB | $15,987 | |
| BPD/DS | $36,160 | |
| VSG | $18,788 | |
| RYGB | $24,277 | |
| Annual inflation rate | 0.00% | |
| Reoperation rates | | [14] |
| LAGB | 14.86% | |
| BPD/DS | 9.20% | |
| VSG | 2.00% | |
| RYGB | 6.20% | |

**Table 1** (continued)

| General population model parameters | Base case | References |
|---|---|---|
| Reoperation costs | | [14] |
| LAGB | $1478 | |
| BPD/DS | $893 | |
| VSG | $402 | |
| RYGB | $787 | |
| Complication rates | | [14] |
| LAGB | 17.90% | |
| BPD/DS | 24.50% | |
| VSG | 9.50% | |
| RYGB | 19.40% | |
| Complication costs severely obese | | [14] |
| LAGB | $4380 | |
| BPD/DS | $5735 | |
| VSG | $4977 | |
| RYGB | $4845 | |
| Complication costs morbidly obese | | [14] |
| LAGB | $5356 | |
| BPD/DS | $6711 | |
| VSG | $5952 | |
| RYGB | $5820 | |
| T2DM resolution rates | | |
| LAGB | 47.90% | [23] |
| BPD/DS | 95.00% | [26] |
| VSG | 90.00% | [24, 25] |
| RYGB | 83.70% | [23] |
| T2DM model parameters[a] | | |
| Demographics | | |
| BMI prevalence in year 1 | | [21] |
| Normal | 25.00% | |
| Overweight | 17.00% | |
| Obese | 13.50% | |
| Severely obese | 17.00% | |
| Morbidly obese | 27.50% | |
| Proportion of BMI w/ T2DM (across all BMI groups) | 100% | Model assumption |
| BMI prevalence average growth rate (T2DM) | 0% | |
| Health plan's annual BMI-specific costs | | [27] |
| Normal | $2317 | |
| Overweight | $2726 | |
| Obese | $4261 | |
| Severely obese | $7253 | |
| Morbidly obese | $10,660 | |
| Surgery | | |
| Surgery prevalence | | [30] |
| LAGB | 0.70% | |
| BPD/DS | 0.40% | |
| VSG | 14.70% | |
| RYGB | 84.20% | |

*BPD/DS* biliopancreatic bypass w/ duodenal switch, *LAGB* band/laparoscopic adjustable gastric banding, *RYGB* Roux-en-Y gastric bypass, *VSG* sleeve/vertical sleeve gastrectomy

[a] Rest of the model parameters not displayed here are same as the general population model

## Budget-Restricted Coverage

When bariatric surgery expenditures were limited to $0.5 million/annum, a total of 238 procedures were performed during the study period, averaging 24 per year. Because surgery-eligible patients with T2DM are prioritized, of the 476 surgeries, roughly 238 were performed on diabetic patients, with 199 having T2DM resolution. The cumulative impact was estimated at − $6.5 million, with the inflection and breakeven years calculated at years 3 and 5, respectively. Undiscounted

**Table 2** Projected population and total healthcare expenditures—stratified by BMI

| Year | Normal and underweight | | Overweight | | Obese | | Severely obese | | Morbidly obese | | Total healthcare expenditures[a] | Total healthcare expenditures (discounted) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | $ | *N* | $ | *N* | $ | *N* | $ | *N* | $ | | |
| General population | | | | | | | | | | | | |
| 1 | 31,300 | $72,526,052 | 33,000 | $89,970,189 | 20,400 | $86,925,034 | 9000 | $65,279,226 | 6300 | $67,156,554 | $381,857,054 | $381,857,054 |
| 2 | 31,287 | $76,123,071 | 32,967 | $94,405,518 | 20,427 | $91,422,927 | 9012 | $70,307,050 | 6308 | $72,365,053 | $404,623,620 | $392,838,466 |
| 3 | 31,273 | $79,898,260 | 32,934 | $99,059,704 | 20,453 | $96,153,779 | 9023 | $75,722,383 | 6316 | $77,977,974 | $428,812,099 | $404,196,531 |
| 4 | 31,259 | $83,860,430 | 32,901 | $103,943,559 | 20,480 | $101,129,666 | 9035 | $81,555,111 | 6325 | $84,026,756 | $454,515,522 | $415,946,089 |
| 5 | 31,246 | $88,018,831 | 32,868 | $109,068,427 | 20,506 | $106,363,293 | 9047 | $87,837,431 | 6333 | $90,545,287 | $481,833,270 | $428,102,620 |
| 6 | 31,232 | $92,383,169 | 32,835 | $114,446,216 | 20,533 | $111,868,026 | 9059 | $94,604,022 | 6341 | $97,570,093 | $510,871,525 | $440,682,265 |
| 7 | 31,218 | $96,963,627 | 32,802 | $120,089,420 | 20,560 | $117,657,922 | 9070 | $101,892,243 | 6349 | $105,140,542 | $541,743,753 | $453,701,864 |
| 8 | 31,204 | $101,770,895 | 32,770 | $126,011,153 | 20,586 | $123,747,770 | 9082 | $109,742,334 | 6358 | $113,299,068 | $574,571,220 | $467,178,982 |
| 9 | 31,190 | $106,816,187 | 32,737 | $132,225,177 | 20,613 | $130,153,125 | 9094 | $118,197,646 | 6366 | $122,091,411 | $609,483,547 | $481,131,940 |
| 10 | 31,176 | $112,111,274 | 32,704 | $138,745,936 | 20,640 | $136,890,351 | 9106 | $127,304,874 | 6374 | $131,566,872 | $646,619,307 | $495,579,856 |
| T2DM population | | | | | | | | | | | | |
| 1 | 25,000 | $63,296,883 | 17,000 | $57,715,249 | 13,500 | $77,682,538 | 17,000 | $176,080,419 | 27,500 | $419,341,848 | $794,116,937 | $794,116,937 |
| 2 | 24,942 | $66,306,472 | 16,983 | $60,540,410 | 13,518 | $81,672,701 | 17,022 | $189,532,523 | 27,536 | $451,378,517 | $849,430,624 | $824,689,926 |
| 3 | 24,883 | $69,458,458 | 16,966 | $63,503,863 | 13,535 | $85,867,820 | 17,044 | $204,012,334 | 27,572 | $485,862,707 | $908,705,181 | $856,541,787 |
| 4 | 24,824 | $72,759,538 | 16,949 | $66,612,377 | 13,553 | $90,278,420 | 17,066 | $219,598,366 | 27,607 | $522,981,403 | $972,230,105 | $889,728,271 |
| 5 | 24,766 | $76,216,725 | 16,932 | $69,873,053 | 13,570 | $94,915,571 | 17,089 | $236,375,132 | 27,643 | $562,935,875 | $1,040,316,357 | $924,307,609 |
| 6 | 24,707 | $79,837,359 | 16,915 | $73,293,339 | 13,588 | $99,790,910 | 17,111 | $254,433,602 | 27,679 | $605,942,769 | $1,113,297,978 | $960,340,616 |
| 7 | 24,648 | $83,629,124 | 16,898 | $76,881,048 | 13,606 | $104,916,670 | 17,133 | $273,871,693 | 27,715 | $652,235,281 | $1,191,533,816 | $997,890,812 |
| 8 | 24,589 | $87,600,059 | 16,881 | $80,644,375 | 13,623 | $110,305,715 | 17,155 | $294,794,805 | 27,751 | $702,064,426 | $1,275,409,381 | $1,037,024,541 |
| 9 | 24,530 | $91,758,583 | 16,864 | $84,591,917 | 13,641 | $115,971,568 | 17,178 | $317,316,392 | 27,787 | $755,700,393 | $1,365,338,853 | $1,077,811,098 |
| 10 | 24,470 | $96,113,504 | 16,848 | $88,732,692 | 13,659 | $121,928,447 | 17,200 | $341,558,571 | 27,823 | $813,434,014 | $1,461,767,228 | $1,120,322,862 |

*N* BMI category's sample size in the model

[a] Total healthcare expenditures = sum of normal and underweight, overweight, obese, severely obese and morbidly obese groups' expected expenditures

**Table 3** Projected budget impact summary results (general population)

| Year | Surgeries Performed | Surgery Cost | Non-T2DM Healthcare Cost Savings | T2DM Cost Savings | Annual Net Impact[a] | Cumulative Net Impact | Cumulative Net Impact (Discounted)[d] | Total Healthcare Expenditures[b] | Total Healthcare Expenditures (Discounted)[d] | Δ PMPM (vs. No-Coverage)[c] | Δ PMPM (vs. No-Coverage; Discounted)[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Unrestricted Surgery Coverage*** | | | | | | | | | | | |
| 1 | 217 | $4,555,986 | $0 | -$198,084 | $4,357,902 | $4,357,902 | $4,357,902 | $386,214,956 | $386,214,956 | $3.63 | $3.63 |
| 2 | 218 | $4,561,909 | -$635,480 | -$406,271 | $3,520,158 | $7,878,060 | $7,648,602 | $408,143,778 | $396,256,095 | $2.93 | $2.85 |
| 3 | 218 | $4,567,839 | -$1,381,012 | -$625,614 | $2,561,214 | $10,439,274 | $9,840,017 | $431,373,314 | $406,610,721 | $2.13 | $2.01 |
| 4 | 218 | $4,573,778 | -$2,381,006 | -$857,245 | $1,335,526 | $11,774,800 | $10,775,610 | $455,851,048 | $417,168,284 | $1.11 | $1.02 |
| 5 | 218 | $4,579,724 | -$3,538,481 | -$1,102,389 | -$61,146 | $11,713,654 | $10,407,430 | $481,772,124 | $428,048,292 | -$0.05 | -$0.05 |
| 6 | 219 | $4,585,677 | -$4,623,983 | -$1,362,361 | -$1,400,666 | $10,312,987 | $8,896,074 | $509,470,859 | $439,474,038 | -$1.17 | -$1.01 |
| 7 | 219 | $4,591,639 | -$5,765,921 | -$1,638,584 | -$2,812,866 | $7,500,121 | $6,281,234 | $538,930,887 | $451,346,133 | -$2.34 | -$1.96 |
| 8 | 219 | $4,597,608 | -$6,969,468 | -$1,932,592 | -$4,304,452 | $3,195,669 | $2,598,371 | $570,266,768 | $463,679,068 | -$3.59 | -$2.92 |
| 9 | 220 | $4,603,585 | -$8,240,164 | -$2,246,042 | -$5,882,621 | -$2,686,952 | -$2,121,105 | $603,600,925 | $476,488,144 | -$4.90 | -$3.87 |
| 10 | 220 | $4,609,569 | -$9,583,946 | -$2,580,723 | -$7,555,099 | -$10,242,052 | -$7,849,680 | $639,064,208 | $489,789,502 | -$6.30 | -$4.83 |
| ***Budget Restricted Surgery Coverage*** | | | | | | | | | | | |
| 1 | 24 | $500,000 | $0 | -$125,687 | $374,313 | $374,313 | $374,313 | $382,231,368 | $382,231,368 | $0.31 | $0.31 |
| 2 | 24 | $500,000 | -$81,921 | -$256,715 | $161,364 | $535,678 | $520,075 | $404,784,984 | $392,995,131 | $0.13 | $0.13 |
| 3 | 24 | $500,000 | -$177,914 | -$393,618 | -$71,533 | $464,145 | $437,501 | $428,740,567 | $404,129,104 | -$0.06 | -$0.06 |
| 4 | 24 | $500,000 | -$306,568 | -$536,966 | -$343,534 | $120,611 | $110,376 | $454,171,988 | $415,631,707 | -$0.29 | -$0.26 |
| 5 | 24 | $500,000 | -$455,324 | -$687,365 | -$642,689 | -$522,077 | -$463,859 | $481,190,581 | $427,531,599 | -$0.54 | -$0.48 |
| 6 | 24 | $500,000 | -$594,558 | -$845,465 | -$940,023 | -$1,462,101 | -$1,261,221 | $509,931,502 | $439,871,393 | -$0.78 | -$0.68 |
| 7 | 24 | $500,000 | -$740,820 | -$1,011,959 | -$1,252,780 | -$2,714,880 | -$2,273,669 | $540,490,974 | $452,652,681 | -$1.04 | -$0.87 |
| 8 | 24 | $500,000 | -$894,747 | -$1,187,591 | -$1,582,338 | -$4,297,218 | -$3,494,032 | $572,988,882 | $465,892,396 | -$1.32 | -$1.07 |
| 9 | 24 | $500,000 | -$1,057,022 | -$1,373,153 | -$1,930,176 | -$6,227,394 | -$4,915,962 | $607,553,371 | $479,608,242 | -$1.61 | -$1.27 |
| 10 | 24 | $500,000 | -$1,228,375 | -$1,569,497 | -$2,297,872 | -$8,525,266 | -$6,533,906 | $644,321,435 | $493,818,729 | -$1.91 | -$1.47 |
| ***Quantity Restricted Surgery Coverage*** | | | | | | | | | | | |
| 1 | 100 | $2,101,894 | $0 | -$198,084 | $1,903,809 | $1,903,809 | $1,903,809 | $383,760,864 | $383,760,864 | $1.59 | $1.59 |
| 2 | 100 | $2,101,871 | -$325,511 | -$406,271 | $1,370,089 | $3,273,898 | $3,178,542 | $405,993,709 | $394,168,649 | $1.14 | $1.11 |
| 3 | 100 | $2,101,848 | -$706,775 | -$625,614 | $769,459 | $4,043,357 | $3,811,252 | $429,581,559 | $404,921,820 | $0.64 | $0.60 |
| 4 | 100 | $2,101,825 | -$1,217,609 | -$857,245 | $26,971 | $4,070,329 | $3,724,927 | $454,542,494 | $415,970,772 | $0.02 | $0.02 |
| 5 | 100 | $2,101,802 | -$1,808,026 | -$1,102,389 | -$808,612 | $3,261,717 | $2,897,993 | $481,024,658 | $427,384,178 | -$0.67 | -$0.60 |
| 6 | 100 | $2,101,779 | -$2,360,258 | -$1,362,361 | -$1,620,840 | $1,640,876 | $1,415,434 | $509,250,685 | $439,284,114 | -$1.35 | -$1.17 |
| 7 | 100 | $2,101,756 | -$2,940,050 | -$1,638,584 | -$2,476,878 | -$836,002 | -$700,138 | $539,266,875 | $451,627,518 | -$2.06 | -$1.73 |
| 8 | 100 | $2,101,732 | -$3,549,891 | -$1,932,592 | -$3,380,751 | -$4,216,752 | -$3,428,606 | $571,190,469 | $464,430,122 | -$2.82 | -$2.29 |
| 9 | 100 | $2,101,708 | -$4,192,443 | -$2,246,042 | -$4,336,777 | -$8,553,529 | -$6,752,235 | $605,146,770 | $477,708,449 | -$3.61 | -$2.85 |
| 10 | 100 | $2,101,684 | -$4,870,552 | -$2,580,723 | -$5,349,591 | -$13,903,120 | -$10,655,583 | $641,269,716 | $491,479,841 | -$4.46 | -$3.42 |

Dark Grey cells – Inflection point year
Light Grey cells – Breakeven year
[a] Annual Net Impact = Surgery Cost - Non-T2DM Healthcare Cost Savings - T2DM Cost Savings
[b] Total Net Healthcare Expenditures = Total Healthcare Expenditures (Expected) + Surgery Cost - Non-T2DM Healthcare Cost Savings - T2DM Cost Savings
[c] ΔPMPM = [Scenario/Year's Total Net Healthcare Expenditures - No surgery coverage's Total Net Healthcare Expenditures]÷(100,000*12)
[d] Discounting present value = $X \div (1 + r)^t$ where X is the outcome of interest, r is the discount rate (3%), and t is the number of years into the future X occurs
PMPM: per-member-per-month

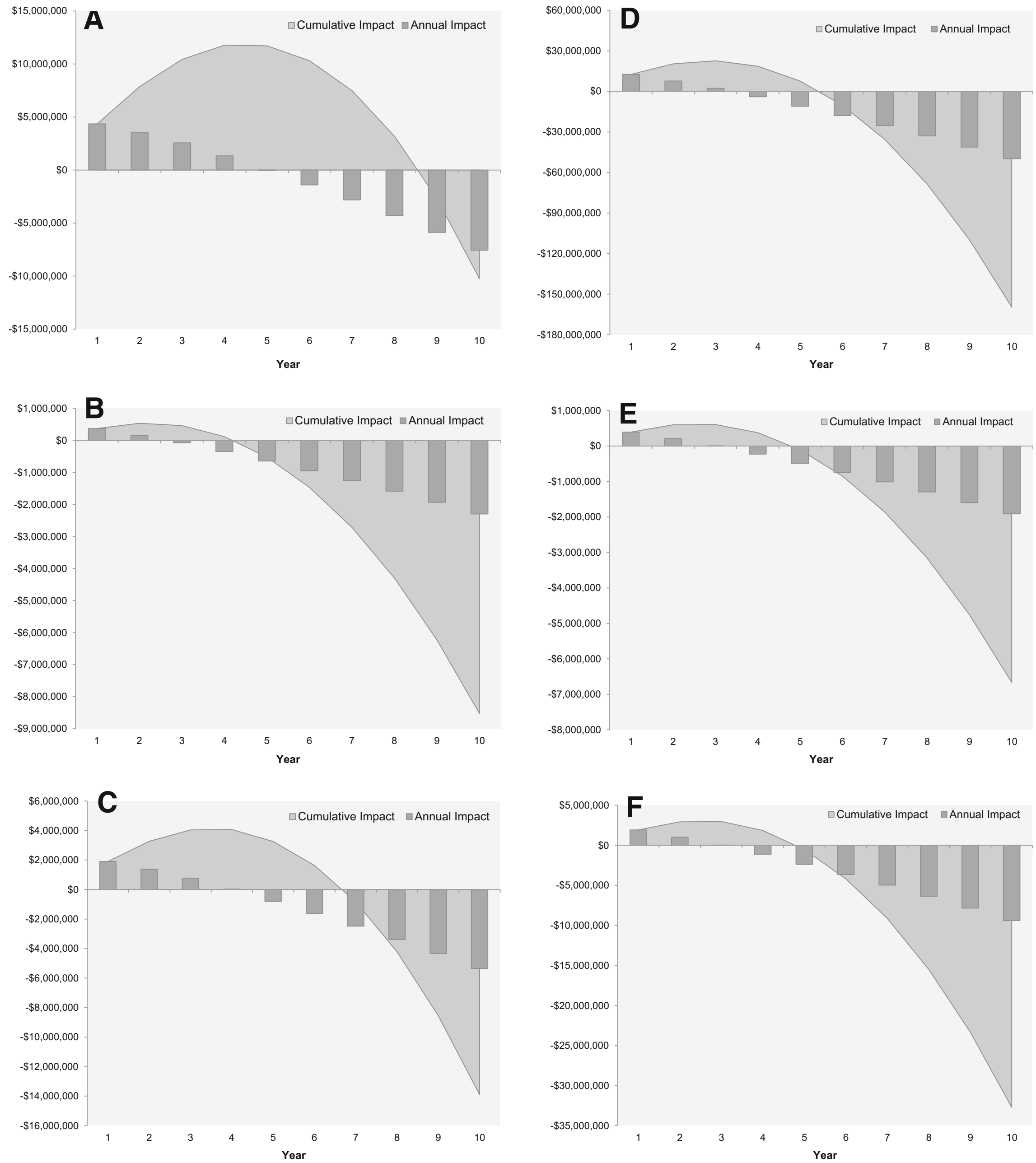


**Fig. 1** Projected budget Impact: **a** Unrestricted coverage, **b** budget-restricted coverage, and **c** Quantity-restricted coverage in general population. **d** Unrestricted coverage, **e** budget-restricted coverage, and **f** quantity-restricted coverage in T2DM Population. Data are presented in Table 3 (**a**–**c**) and in Table 4 (**d**–**f**). Specifically, the undiscounted net annual and cumulative impacts for the different scenarios are visualized in these graphs

general non-T2DM and T2DM cumulative savings were estimated at $5.5 and $8.0 million, respectively. Net healthcare costs increased by $262.1 million from $382.2 million leading to a PMPM (vs. nonsurgical scenario) change from an additional $0.3 (year 1) to − $1.5 (year 10).

## Quantity-Restricted Coverage

In a scenario limited to 100 surgeries/annum, approximately $21.0 million was spent towards surgery costs leading to estimated aggregated undiscounted savings of $34.9 million, of which $12.9 were T2DM-attributable. Nearly 480 (255 morbidly obese and 225 severely obese) diabetic patients were allowed first to receive surgery leading to 401 T2DM resolutions and subsequent savings. The cumulative impact of the scenario was calculated at − $10.7 million, with a breakeven around year 7, while the first occurrence of savings was observed halfway through the year. While net healthcare costs increased by $257.5 million to $641.3 million in 10 years, incremental PMPM (vs. nonsurgical

**Table 4** Projected budget impact summary results (T2DM population)

| Year | Surgeries performed | Surgery cost | Non-T2DM healthcare cost savings | T2DM cost savings | Annual net impact[a] | Cumulative net impact | Cumulative net impact (discounted)[d] | Total healthcare expenditures[b] | Total healthcare expenditures (discounted)[d] | Δ PMPM (vs. no-coverage)[c] | Δ PMPM (vs. no-coverage; discounted)[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unrestricted surgery coverage | | | | | | | | | | | |
| 1 | 632 | $15,470,709 | $0 | − $2,848,899 | $12,621,811 | $12,621,811 | $12,621,811 | $242,021,624 | $806,738,747 | $10.52 | $10.52 |
| 2 | 633 | $15,490,821 | − $1,964,253 | − $5,822,857 | $7,703,711 | $20,325,522 | $19,733,517 | $257,140,301 | $832,169,257 | $6.42 | $6.23 |
| 3 | 634 | $15,510,959 | − $4,268,675 | − $8,934,438 | $2,307,847 | $22,633,369 | $21,334,121 | $273,303,908 | $858,717,154 | $1.92 | $1.81 |
| 4 | 634 | $15,531,124 | − $7,359,636 | − $12,197,067 | − $4,025,579 | $18,607,790 | $17,028,763 | $290,461,358 | $886,044,296 | − $3.35 | − $3.07 |
| 5 | 635 | $15,551,314 | − $10,937,364 | − $15,625,101 | − $11,011,150 | $7,596,639 | $6,749,515 | $308,791,562 | $914,524,344 | − $9.18 | − $8.15 |
| 6 | 636 | $15,571,531 | − $14,292,624 | − $19,233,901 | − $17,954,994 | − $10,358,355 | − $8,935,208 | $328,602,895 | $944,852,480 | − $14.96 | − $12.91 |
| 7 | 637 | $15,591,774 | − $17,822,328 | − $23,039,915 | − $25,270,469 | − $35,628,825 | − $29,838,580 | $349,879,004 | $976,727,192 | − $21.06 | − $17.64 |
| 8 | 638 | $15,612,043 | − $21,542,465 | − $27,060,759 | − $32,991,181 | − $68,620,006 | − $55,794,344 | $372,725,460 | $1,010,199,692 | − $27.49 | − $22.35 |
| 9 | 639 | $15,632,339 | − $25,470,158 | − $31,315,315 | − $41,153,134 | − $109,773,140 | − $86,655,930 | $397,255,716 | $1,045,324,434 | − $34.29 | − $27.07 |
| 10 | 639 | $15,652,661 | − $29,623,755 | − $35,823,825 | − $49,794,919 | − $159,568,059 | − $122,295,630 | $423,591,693 | $1,082,159,203 | − $41.50 | − $31.80 |
| Budget-restricted surgery coverage | | | | | | | | | | | |
| 1 | 20 | $500,000 | $0 | − $108,832 | $391,168 | $391,168 | $391,168 | $794,508,105 | $794,508,105 | $0.33 | $0.33 |
| 2 | 20 | $500,000 | − $70,234 | − $222,288 | $207,477 | $598,646 | $581,210 | $849,638,101 | $824,891,360 | $0.17 | $0.17 |
| 3 | 20 | $500,000 | − $152,533 | − $340,832 | $6634 | $605,280 | $570,535 | $908,711,816 | $856,548,040 | $0.01 | $0.01 |
| 4 | 20 | $500,000 | − $262,834 | − $464,956 | − $227,790 | $377,490 | $345,457 | $972,002,315 | $889,519,811 | − $0.19 | − $0.17 |
| 5 | 20 | $500,000 | − $390,368 | − $595,187 | − $485,554 | − $108,064 | − $96,014 | $1,039,830,803 | $923,876,200 | − $0.40 | − $0.36 |
| 6 | 20 | $500,000 | − $509,739 | − $732,085 | − $741,824 | − $849,888 | − $733,121 | $1,112,556,155 | $959,700,712 | − $0.62 | − $0.53 |
| 7 | 20 | $500,000 | − $635,135 | − $876,252 | − $1,011,387 | − $1,861,275 | − $1,558,789 | $1,190,522,428 | $997,043,791 | − $0.84 | − $0.71 |
| 8 | 20 | $500,000 | − $767,104 | − $1,028,330 | − $1,295,434 | − $3,156,709 | − $2,566,694 | $1,274,113,947 | $1,035,971,235 | − $1.08 | − $0.88 |
| 9 | 20 | $500,000 | − $906,228 | − $1,189,008 | − $1,595,237 | − $4,751,946 | − $3,751,230 | $1,363,743,616 | $1,076,551,804 | − $1.33 | − $1.05 |
| 10 | 20 | $500,000 | − $1,053,136 | − $1,359,022 | − $1,912,157 | − $6,664,103 | − $5,107,480 | $1,459,855,070 | $1,118,857,353 | − $1.59 | − $1.22 |
| Quantity-restricted surgery coverage | | | | | | | | | | | |
| 1 | 100 | $2,454,972 | $0 | − $534,357 | $1,920,615 | $1,920,615 | $1,920,615 | $796,037,552 | $796,037,552 | $1.60 | $1.60 |
| 2 | 100 | $2,454,972 | − $344,846 | − $1,091,424 | $1,018,703 | $2,939,318 | $2,853,707 | $850,449,326 | $825,678,958 | $0.85 | $0.82 |
| 3 | 100 | $2,454,972 | − $748,930 | − $1,673,468 | $32,574 | $2,971,892 | $2,801,293 | $908,737,755 | $856,572,491 | $0.03 | $0.03 |
| 4 | 100 | $2,454,972 | − $1,290,498 | − $2,282,910 | − $1,118,436 | $1,853,455 | $1,696,174 | $971,111,668 | $888,704,744 | − $0.93 | − $0.85 |
| 5 | 100 | $2,454,972 | − $1,916,684 | − $2,922,333 | − $2,384,044 | − $530,589 | − $471,422 | $1,037,932,313 | $922,189,416 | − $1.99 | − $1.77 |
| 6 | 100 | $2,454,972 | − $2,502,791 | − $3,594,495 | − $3,642,314 | − $4,172,903 | − $3,599,583 | $1,109,655,665 | $957,198,724 | − $3.04 | − $2.62 |
| 7 | 100 | $2,454,972 | − $3,118,480 | − $4,302,347 | − $4,965,855 | − $9,138,758 | − $7,653,566 | $1,186,567,961 | $993,731,987 | − $4.14 | − $3.47 |
| 8 | 100 | $2,454,972 | − $3,766,435 | − $5,049,045 | − $6,360,509 | − $15,499,266 | − $12,602,322 | $1,269,048,872 | $1,031,852,865 | − $5.30 | − $4.31 |
| 9 | 100 | $2,454,972 | − $4,449,531 | − $5,837,965 | − $7,832,523 | − $23,331,790 | − $18,418,330 | $1,357,506,330 | $1,071,628,032 | − $6.53 | − $5.15 |
| 10 | 100 | $2,454,972 | − $5,170,838 | − $6,672,720 | − $9,388,586 | − $32,720,376 | − $25,077,443 | $1,452,378,641 | $1,113,127,292 | − $7.82 | − $6.00 |

Dark gray cells—inflection point year, light gray cells—breakeven year

*PMPM* per-member-per-month

[a] Annual net impact = Surgery cost − Non-T2DM healthcare cost savings − T2DM cost savings

[b] Total net healthcare expenditures = Total healthcare expenditures (expected) + Surgery cost − Non-T2DM healthcare cost savings − T2DM cost savings

[c] ΔPMPM = For each year, [Scenario's total net healthcare expenditures − No surgery coverage's total net healthcare expenditures] / (100,000 × 12)

[d] Discounting present value = / (1 + ) , where *X* is the outcome of interest, *r* is the discount rate (3%), and *t* is the number of years into the future *X* occurs

approach) was estimated to change from an additional \$1.6 (year 1) to − \$3.4 (year 10).

## T2DM Model

### No Surgery Coverage

In a 100,000-member model where every member was diagnosed with T2DM, annual healthcare costs were projected to increase from \$794.1 million to \$1.1 billion over the next 10 years in the absence of bariatric surgery with the disease contributing more than one third of the costs overall (Table 2). The general non-T2DM healthcare portion of the net costs increased by roughly 40%. While the severe and morbidly obese numbers in the plan increased by 1.2%, their contribution increased by 4% points, up from 75.0% during the first year of the model.

### Unrestricted Coverage

A total of 6356 procedures would be performed, averaging 636 per year at an undiscounted cost of \$15.6 million/annum and lead to a cumulative impact of − \$122.3 million and inflection and breakeven occurring during years 4 and 6, respectively (Table 4; Fig. 1). The undiscounted aggregated general non-T2DM cost savings were calculated at \$133.3 million, while the 84.4% (5366) whose T2DM was resolved led to undiscounted savings at \$181.9 million. The net healthcare costs went up by 34.1% to \$1.1 billion while the incremental PMPM (vs. nonsurgical scenario) ranged from + \$10.5 in year 1 to − \$31.8.

### Budget-Restricted Coverage

When no more than \$0.5 million was allotted to bariatric surgeries and any related post-operative complications and reoperations, a total of 204 surgeries were performed with 172 T2DM resolutions during the 10-year study period. General non-T2DM and T2DM aggregated savings (undiscounted) were estimated at \$4.7 and \$6.9 million, respectively. Net healthcare costs increased \$794.5 million (year 1) to \$1.1 billion (year 10), with the corresponding delta PMPM estimated to change from an additional \$0.3 to − \$1.2 when compared against our comparator scenario. The cumulative impact was estimated at − \$5.1 million, with the inflection and breakeven years calculated during years 4 and 5, respectively.

### Quantity-Restricted Coverage

When 100 surgeries were performed every year on eligible members electing to receive the surgery, surgery costs averaged \$2.5 million/annum leading to undiscounted aggregated savings of \$57.3 million, 59.3% T2DM attributable. The cumulative impact of the scenario was calculated at − \$25.1 million, with the inflection and breakeven years occurring during the fourth and fifth years of the model timeline. The differential cost PMPM compared to nonsurgical approach was estimated to reduce from + \$1.6 (year 1) to − \$6.0 (year 10).

## Sensitivity Analyses

One-way sensitivity analysis found the general population's 10-year BI model was most sensitive to the following: surgery costs (VSG, RYGB), surgery member attrition, surgery eligible BMI-related proportion and associated costs, and surgery election rate (Appendix Fig. 2). Depending on the scenario under consideration, their order of impact changed. For instance, where surgery costs and member attrition were the primary drivers in the unrestricted scenario, the attrition rate along with morbidly obese group's related costs were highly relevant to the two restricted scenarios. The results of the sensitivity analysis also establish the robustness of the model indicating that cost savings were consistently achieved even with ± 25% variation of the baseline parameters.

# Discussion

Due to increasing financial constraints in the US healthcare system, efforts are underway to inform decision makers and caregivers about the economic consequences of interventions to payers and health systems and ensure that they are either cost-saving or cost-effective in order to support their implementation [33]. This economic model was intended to estimate the short- and long-term financial impact of allowing access to bariatric surgery under different medical benefit plan scenarios by a health plan payer or health system to inform decision-making about fund allocation. The present study extends understanding of the economic impact of bariatric surgery by incorporating some of the current major trends in obesity in the USA (e.g., obesity rates that are high but fairly stable over time) and bariatric surgery trends in actual practice. Our findings indicate that providing unrestricted surgery access to eligible patients in a 100,000-member health plan with a 15.3% surgery-eligible prevalence rate (and nearly half of them with T2DM) leads to 10-year cumulative undiscounted cost savings of \$10.2 million (\$7.8 million if discounted) for a total investment of \$45.8 million. Restricting by budget costs (0.5 million/annum) or by frequency (100/annum) leads to \$6.5 to \$10.7 million cumulative savings, respectively. The benefits were even more pronounced with larger net savings (\$1.2 to \$31.8 PMPM) and a faster breakeven (5–6 years) when offered to patient subgroups with very high obesity-related costs, like those with T2DM. Providing unlimited surgery access to a 100,000 T2DM member health plan with a 44.5% surgery-eligible prevalence rate had a 10-year cumulative cost savings of $122.3 million compared to the $5.1 to $25.1 million savings when restricted by budget (0.5 million/annum) or by frequency (100/annum). It appears that in a scenario where access restrictions need to be in place, frequency limits may offer higher net benefits.

To our knowledge, only a few BI models have been developed for obesity treatments, all European-based and none for the USA. Ackroyd et al. compared the 5-year budgetary impact of gastric banding and bypass surgery over conventional therapy involving diet and drugs in a T2DM cohort of 1000 patients with BMI ≥ 35 kg/m$^2$ in Germany (€3.6 and €5.0 million net savings, respectively), France (€4.5 and €5.9 million net savings, respectively), and the UK (£2.0 to £2.03 million more expensive, respectively) [34]. The same model was replicated by Anselmino et al. for Austria (€2.9 and €1.9 million net savings, respectively), Italy (€1.1 and €1.7 million net savings, respectively), and Spain (€1.5 to €3.6 million more expensive, respectively) [35]. The findings concluded that the additional spending in 1 year usually generated a net saving after 5 years with the exception of the UK and Spain. Borg and colleagues assessed different annual policies for surgical operations in Swedish subjects with BMI > 40 versus no surgical operation [36]. From the Swedish healthcare perspective, 3000 surgical operations in persons with BMI > 40 resulted in a net BI of SEK 40,000/patient, offsetting 55% of the surgery cost by reducing excess treatment costs of obesity-related diseases. They found that expanding annual surgery limits from 3000 to 4000 increased the cost-offset to 58% while no benefits were obtained by escalating further to 5000 and to those with BMI > 35, thereby concluding that a cost-minimization bariatric strategy should not expand indication, but rather increase the number of surgeries within the BMI > 40 group. Our analysis is consistent with the above findings that providing bariatric surgery coverage required an initial economic investment ($0.3 to $3.6 PMPM) but may start saving money within a relatively short period of time (3–5 years), and breakeven shortly after (years 5–9 in the model).

## Limitations

The study drew on recently published and authoritative estimates of the effects and costs of bariatric surgery with an emphasis on the current trends of bariatric surgical procedures. But the study has some important limitations. First, we acknowledge that our decision-analytic model was a simplified representation of a US health plan payer or health system and ideally the sources of information about cost and clinical benefits of comparative treatment strategies should be derived from randomized controlled trials. Second, heterogeneity was not specifically considered by simulating a homogeneous cohort of surgery patients and not distinguishing between the different patient populations who may have better or worse outcomes (e.g., mortality) from surgical intervention. Third, the model also anticipated zero cost sharing assuming that in a typical medical plan, members pursuing surgery were likely to have met their deductible/coinsurance limits. If member sharing option was available, then conventional wisdom suggests that a faster breakeven can be achieved owing to lesser investment plan dollars rendering our results conservative. Our model did not specifically categorize benefits from non-T2DM obesity-related diseases (e.g., obstructive sleep apnea, cancer and musculoskeletal and gynecology disorders) nor any other ‘spillover’ benefits because we lacked sufficient data on these conditions.

## Conclusion

Benefits gained through bariatric surgery may be obtained at a reasonable and affordable cost and providing coverage lead to a net cost saving effect to the US managed care model over a 10-year period. The year 1 impact of covering bariatric surgery under multiple scenarios for a general (T2DM) population ranged from an additional $0.3 to $3.6 (T2DM: $0.3 to $10.5) PMPM. However, with the payer breaking-even between years 5 and 9 (T2DM: 5-6), the trend reversed and delta PMPM cost savings are expected to range between $1.5 and $4.8 (T2DM: $1.2 and $31.8) by year 10. Providing bariatric surgery coverage may have a modest short-term BI increase but would lead to long-term net cost savings in a general population model. The results were much more pronounced in the T2DM model with larger net savings and a quicker breakeven timeline.

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### Compliance with Ethical Standards

**Blinded Conflict of Interest Statement, Ethical Statement and Consent Statement** This study was funded by Ethicon, Inc. At the time of the analysis Author 1 was an employee of, and Author 2 is currently a consultant to, CTI Clinical Trial and Consulting Services, which is a paid consultant to Ethicon, Inc. Author 3 is an employee of Ethicon, Inc., the study sponsor.

This article does not contain any studies with human participants or animals performed by any of the authors. For this type of study, formal consent is not required.

## Appendix

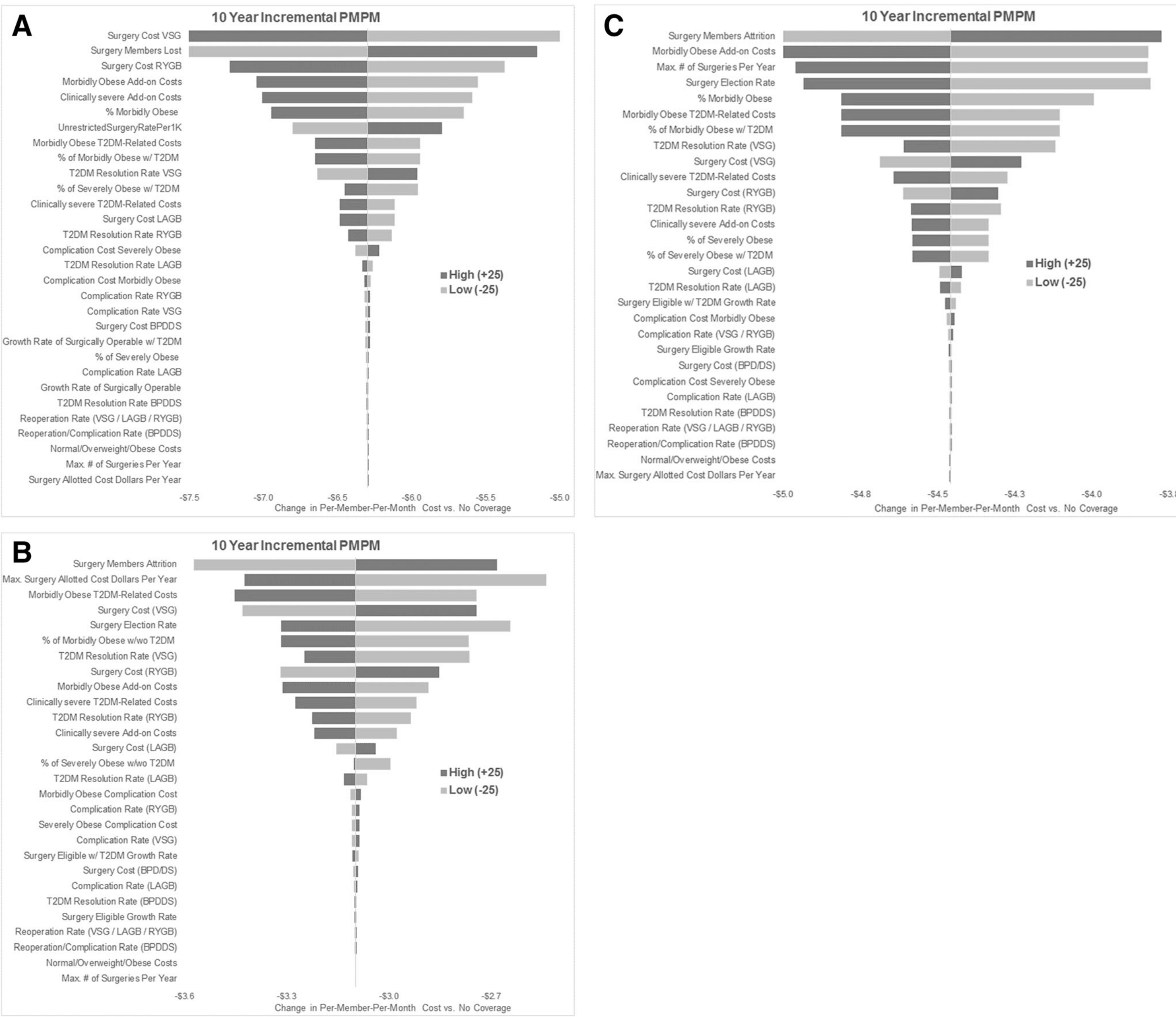


**Fig. 2** Sensitivity analysis for the general population model. **a** Unrestricted surgery coverage. **b** Budget-restricted coverage. **c** Quantity-restricted coverage. BPD/DS biliopancreatic bypass w/ duodenal switch, LAGB band/laparoscopic adjustable gastric banding, PMPM per-member-per-month, RYGB Roux-en-Y gastric bypass, VSG sleeve/vertical sleeve gastrectomy

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