

Impact of weight trajectory after bariatric surgery on co-morbidity evolution and burden

Jason Davis (✉ jason@coreva-scientific.com)

Coreva Scientific <https://orcid.org/0000-0003-4672-068X>

Rhodri Saunders

Coreva Scientific

Research article

Keywords: Trajectory, burden, bariatric surgery, gastric bypass, sleeve gastrectomy, diabetes, hypertension

Posted Date: July 3rd, 2019

DOI: <https://doi.org/10.21203/rs.2.10974/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published at BMC Health Services Research on April 3rd, 2020. See the published version at <https://doi.org/10.1186/s12913-020-5042-9>.

Abstract

Background Bariatric surgery in its various forms has been shown to be an effective intervention for weight management in select patients. Different types of surgery such as Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy demonstrate different efficacies in weight loss and co-morbidity resolution. Even within a single type of surgery, different patients respond differently and have differing weight-change trajectories post-surgery. The present analysis explores how improving a patient's post-surgical weight change could impact on co-morbidity prevalence, treatment and associated costs in the Canadian setting. **Methods** Published data were used to derive statistical models to predict weight loss and co-morbidity evolution after RYGB. A 100-patient cohort was compared for an optimal versus a poor weight trajectory over a 10-year time horizon after surgery. Costs (2018 CAD\$) were considered from the Canadian public payer perspective for diabetes, hypertension and dyslipidaemia. Robustness of results was assessed using probabilistic sensitivity analyses using the R language. **Results** Models fitted to patient data for total weight loss and co-morbidity evolution (resolution and new onset) demonstrated good fitting. Having a good versus poor weight trajectory resulted in a decreased burden, saving 181, 817, and 530 patient-years of diabetes, hypertension and dyslipidaemia treatment respectively. Cohorts on a good weight trajectory following RYGB had \$1.9 million lower costs at 10 years than those on a poor weight trajectory. **Conclusions** Within a cohort of patients receiving the same type of bariatric surgery, achieving a good versus a poor weight loss trajectory can have a significant impact on outcomes by reducing the number of patient years of co-morbidity treatment and corresponding cost. Given the burden associated with a poor weight trajectory, health care systems should consider how best to ensure that more patients achieve a good long-term weight trajectory after bariatric surgery.

Background

Worldwide, obesity and its management are growing healthcare concerns. Canada faces similar issues with an increasing burden of obesity and related co-morbidities.[1] Being overweight or obese considerably increases the risk of developing diseases such as type 2 diabetes (T2DM), hypertension (HTN), dyslipidaemia, or other forms of cardiovascular disease such as stroke or coronary artery disease. Managing these co-morbidities creates considerable burden for public and private payers in terms of hospital resource usage, physician visits and medications. Considering the chronic diseases most commonly associated with obesity, for example, costs of care in Canada were estimated to have increased by 19% between 2000 and 2008, from \$3.9 to \$4.6 billion.[2]

The ideal treatment must be optimized individually between patient and provider and involves a long-term commitment to improvement of health. Some patients may be supported with diet and exercise, some with medication, and for many patients, a key catalyst to support these lifelong changes is bariatric surgery. Procedures performed in Canada include established surgeries such as Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy, biliopancreatic diversion with or without duodenal switch and adjustable gastric banding, although the latter is decreasing in use.[3, 4] The choice of surgery will impact the

potential range of weight loss a patient may achieve and degree to which co-morbidities are resolved or improved.[5-9]

Among patients who do receive surgery, there is a wide range of outcomes for weight loss and co-morbidity resolution. Differences occur between surgery types, and within the same surgical cohort, where some patients experience good trajectories with considerable early and sustained weight loss with concomitant co-morbidity resolution, while others follow poorer trajectories of lower weight loss and persistent co-morbidities.[10, 11] The latter, poorer weight loss may result in insufficient improvement in weight status to reduce co-morbidity risks, both extending the risks to patient health and maintaining a high burden of care for payers.

The reasons for different weight trajectories after the same type of surgery remain to be elucidated. Factors such as gender, race and genetics have been investigated,[10-12] but with an aim to improving surgical outcomes, these characteristics are not readily modifiable parameters and clinical application of these studies remains to be determined.[12] Other interventions may yet be possible, however, given the observation that early post-surgical results during the time of greatest patient contact have been shown to be a reliable predictor of longer term results [10] and a retrospective audit identified missing post-surgical clinical attendance as a main predictor of poor long-term weight loss.[13]

To date, analyses of the burden of obesity have focused on bariatric surgery versus medical management, or between different types of surgery. The variation in outcomes within a single type of surgery could, however, also be a substantial cost driver. The aim of this study is to provide a first estimate quantifying the differences in patient outcomes and costs between patients following good versus poor weight trajectories in the Canadian setting after RYGB surgery.

Methods

Here, a weight trajectory is the evolution of patient weight after bariatric surgery. A good trajectory is considered that which demonstrates considerable early weight loss that is maintained in the mid- to long-term. A poor weight trajectory shows limited weight loss after surgery, often with significant weight regain after a nadir. For the present analysis, the estimate of the trajectory burden is taken as the difference in prevalence and associated treatment between the good and poor weight loss outcomes. As a first estimate, only the costs of three commonly reported co-morbidities (T2DM, HTN, and dyslipidaemia) were considered owing in part to a lack of data on the evolution of other co-morbidities as a function of post-bariatric surgery weight trajectory. Post-surgical co-morbidity prevalence was determined by considering both resolution in patients with the co-morbidity at baseline and new onset among those who did not. Models were employed, informed by available data, to extrapolate reported outcome results to a 10-year window. The analysis scheme is depicted in Figure 1.

Surgical outcomes

For RYGB, the reported patient outcome data of Courcoulas[10] were used. The authors categorized patients (post-surgery) into 6 groups representing different weight trajectories. Within each group, baseline demographics and total weight loss and co-morbidity resolution (T2DM, hypertension, high LDL cholesterol, low HDL cholesterol, and high triglycerides) were presented up to 7 years post-surgery. In the present study, differences in outcomes were compared between a good (group 6) and poor (group 1) weight trajectory.

Weight loss

To extrapolate total weight loss (TWL), data were plotted separately for the good and poor trajectories and suitable non-polynomial (to reduce risk of overfitting), non-linear models investigated using CurveExpert Professional version 2.6. A yield density model was identified as suitable for both trajectories allowing estimation of TWL (and thereby body mass index [BMI] determination from baseline demographics).

Co-morbidity evolution

In any patient, the presence of a co-morbidity is dependent on numerous factors beyond weight loss. Of these, two factors, age and BMI, were available for use in our model. To make use of as much data as possible for fitting with two independent variables, all group data were included. At each point after surgery, the current (cohort) age was calculated as time after surgery plus baseline age, and BMI was calculated using the yield density model for weight loss. These results were combined with the reported remission rates of Courcoulas for each group at each timepoint after surgery and models were explored. A linear model was found suitable, allowing the estimation of co-morbidity remission as a function of age and BMI after surgery.

For co-morbidity incidence, the data of Courcoulas were not stratified by group given the low patient counts of new onset cases. A model to estimate new cases in patients without the co-morbidity at baseline could thus only be informed by BMI after surgery for the entire cohort, since it is unknown to which trajectory group these cases belong. A linear model was the most suitable, taken to be a conservative estimate somewhere between the good and poor trajectories.

Cost analysis

The overall impact of difference in weight trajectory was taken to be the cumulative number of cases calculated at discrete 1-year intervals over the 10-year period. An initial cohort of 100 patients was divided according to baseline co-morbidity prevalence into those with and those without the co-morbidity (Table 1).

In the group with the co-morbidity at baseline, cases in a given year were taken as the difference between the number of cases not resolved between the poor and the good trajectories. The overall sum over 10 years is defined as the number of patient-years of treatment for non-resolved cases.

Only the group without the co-morbidity at baseline can experience new onset. The incidence is thus applied only to this group to estimate the number of new cases in any given year. Patients who develop new onset disease are assumed to continue to receive treatment in subsequent years up to the end of the time horizon, thereby making the total number of patient-years of treatment for new onset cases the cumulative sum of incident cases in any given year, plus cases still in treatment from previous years.

For both the remission and new onset groups, patients are assumed to remain within their respective groups over the time horizon. Patients with the co-morbidity at baseline who achieve remission therefore remain in that group and are not added to the group at risk for new onset. Similarly, new onset cases cannot achieve remission, as there are no data to inform accurate estimates of this movement.

Input costs are shown in Table 1. All costs are for public payers in the Canadian context. Costs for T2DM and HTN thus include physician and hospital treatments, while those for dyslipidaemia are the public cost of additional lab work for patients receiving statins. An annual discount rate of 1.5% was applied across the 10-year time horizon.

Table 1 Model parameters

Costs from reported currency year were inflated to 2018 Canadian dollars using Statistics Canada consumer price index data for health services and products. HTN, hypertension; LDL, low density lipoprotein; NA, not applicable; RYGB, Roux-en-y gastric bypass; T2DM, type 2 diabetes mellitus

Sensitivity analysis

The robustness of the base case cohort was assessed through probabilistic sensitivity analysis with 10,000 iterations. For each iteration, parameters were sampled using the normal distribution (age, initial BMI, proportion of female patients, the proportion of patients at baseline with T2DM, HTN, or dyslipidaemia, and all cost parameters) according to the mean and standard deviation for each. The 10-year total patient-years of treatment and costs were calculated, from which 95% credibility intervals were determined. Calculations were performed using the R statistical programming language.

Results

Results of the fitting of post-surgical total weight loss are shown in Figure 2. The models describe the source model data well, with coefficients of determination of 0.999 and 0.957 for the good and poor trajectories respectively. As seen in the source study for the current analysis, a patient's weight trajectory after bariatric surgery can influence the occurrence of co-morbidities that may require treatment.[10] Lower rates of successful resolution are observed in the poor versus good post-surgical weight trajectory,

resulting in additional cases requiring treatment. The present analysis considers the additional treatment required if an entire cohort of patients achieves the poorest trajectory versus the outcome if the entire cohort had instead achieved the good trajectory.

The focus here is on chronic co-morbidities: T2DM, HTN, and dyslipidaemia, taken as high LDL cholesterol. Additional cumulative years of treatment for a post-surgical cohort in the poor versus good weight trajectory after RYGB surgery are shown in Figure 3.

The largest treatment differences are observed for HTN, followed by dyslipidaemia and T2DM. Of these co-morbidities, HTN also had the highest baseline prevalence among patients at 69% versus 37% and 35% for high LDL and T2DM respectively. A higher baseline co-morbidity prevalence means fewer patients at risk for developing new onset disease and a higher proportion of patients whose condition can be resolved.

Detailed results 10 years after surgery are shown in Table 2. Among calculations of total number of treatment years, results are stratified into those attributed to patients who had the co-morbidity at baseline and were not resolved, and into the treatment resulting from new onset cases. Costs are similarly divided into those attributable to persistent and new onset cases.

[Location of Table 2]

Discussion

After bariatric surgery, patients experience varying degrees of weight loss. The aim of the present study is to provide a first estimate of the impact of good versus poor weight trajectories on patient outcomes and treatment costs. While many studies may assess entire surgical cohorts as single arm studies, or comparisons against other treatments (surgical or non-surgical) for weight loss and co-morbidity effects, this analysis sought to examine differences among patients who received the same surgery and were at the same risk of surgery-related complications and associated costs, but by some means achieved different weight trajectories.

Our analysis suggests that achieving a good versus a poor weight trajectory has a considerable impact on patient outcomes and treatment costs. For chronic obesity-related co-morbidities, the good trajectory is associated with median \$1.9 million savings (95% credibility interval \$823,832 to \$2,777,124) in public expenditure for RYGB.

As a first detailed investigation of co-morbidity outcomes and cost impact due to variations in weight trajectories after bariatric surgery, the study is not without limitations. The availability of data in the North American setting for post-surgical co-morbidity evolution by weight trajectory permitted the derivation of descriptive models after RYGB, but it must be assumed that the results from this single American cohort also apply to the Canadian setting. Also, the reported post-surgical co-morbidity incidence was not stratified by weight trajectory.[10] If the new cases demonstrated a tendency towards developing in

patients with a poorer weight trajectory, the incidence calculated here would represent an overestimate for the good weight outcome. The resulting calculated difference in incidence between the good and poor trajectories is therefore likely a conservative estimate of the difference in patient-years of treatment.

The cost analysis is also likely a conservative estimate of the true cost impact of a poor versus good post-bariatric surgery weight trajectory. Due in part to availability of detailed data, only chronic conditions (T2DM, HTN, and dyslipidaemia in the form of high LDL cholesterol) were included. Surgery also has an impact on other cost-attributable obesity-related conditions such as cardiovascular disease risk (including myocardial infarction, stroke or heart failure),^[14] osteoarthritis requiring joint replacement surgery^[15] and non-alcoholic fatty liver disease.^[16] Bariatric surgery has been shown for these conditions to have a positive effect in reducing their prevalence, and one might thus expect some corresponding saving in treatment costs, but in the absence of further data, no reasonable estimate could be determined.

There are multiple factors influencing weight loss outcomes after surgery. Among them, genetics in the form of single nucleotide polymorphisms (SNPs),^[11] gender and race have been found to influence weight loss outcomes.^[10] Future studies may identify ways that patient care can be optimized for patients with these different characteristics to improve outcomes. Until such time, providers can focus on other aspects of care that have been shown to be associated with improved weight loss. These include patient behaviours in eating and exercise,^[17] better follow-up attendance^[13, 17, 18] as well as achieving better outcomes at specialist bariatric care centres over non-specialist care.^[19] The present analysis serves as an estimate of what is at stake for providers in terms of patient outcomes and associated costs should post-bariatric surgery trajectories not be optimized. With this information, informed decisions can be made regarding investment in strategies targeted towards modifiable factors of patient behaviour and engagement to achieve improved patient outcomes.

Conclusions

Post-bariatric surgery, patients experience a variety of weight trajectories. Even after the same surgery, patients may achieve a good trajectory with sustained weight loss, or a poor trajectory characterized by poor initial weight loss and varying degrees of weight regain. The trajectory can impact successful co-morbidity resolution, and patient risk of new onset disease. Having a poor weight trajectory increases patient time with comorbidities and leads to increased costs of care. Improving weight trajectories after RYGB was estimated to save providers almost \$2 million per 100 patients. This analysis is an initial estimate of burden, but its results provide justification for debate on whether investment of resources is required to optimize patient weight trajectories, realize better patient co-morbidity outcomes, and ultimately improve and lower the cost of healthcare provision.

List Of Abbreviations

HTN, hypertension; RYGB: Roux-en-y gastric bypass surgery; T2DM, type 2 diabetes mellitus

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

RS and JD are health economics and data analysis consultants who have worked with Medtronic Inc on the current, and other projects.

Funding

The study was funded by Medtronic Inc. Beyond initiation of the study concept, to quantify impact of weight trajectory of patient outcomes and costs, the funding body did not influence the literature sourced, the methods of analysis, or interpretation of the results. The funding body was permitted to view the manuscript before submission but did not have editorial control over the final manuscript.

Authors' contributions

JD performed the data and statistical analyses, interpreted results, and wrote and revised the manuscript. RS contributed to the data interpretation and writing and revision of the manuscript.

Acknowledgements

Not applicable.

References

1. Lebenbaum M, Zaric GS, Thind A, Sarma S: Trends in obesity and multimorbidity in Canada. *Prev Med* 2018, 116:173-179.
2. Corscadden L, Taylor A, Sebold A, Maddocks E, Pearson C, Harvey J, Amuah JE, Walker J, Kwan A, Sommerer S *et al*: Obesity in Canada: A joint report from the Public Health Agency of Canada and the Canadian Institute for Health Information. In.; 2011.
3. Anvari M, Lemus R, Breau R: A Landscape of Bariatric Surgery in Canada: For the Treatment of Obesity, Type 2 Diabetes and Other Comorbidities in Adults. *Can J Diabetes* 2018, 42(5):560-567.
4. Canadian Institute for Health Information: Bariatric Surgery in Canada. In. Ottawa, ON: CIHI; 2014.
5. Colquitt JL, Pickett K, Loveman E, Frampton GK: Surgery for weight loss in adults. *Cochrane Database Syst Rev* 2014(8):CD003641.
6. Huang X, Liu T, Zhong M, Cheng Y, Hu S, Liu S: Predictors of glycemic control after sleeve gastrectomy versus Roux-en-Y gastric bypass: A meta-analysis, meta-regression, and systematic review. *Surg Obes Relat Dis* 2018, 14(12):1822-1831.
7. Li J, Lai D, Wu D: Laparoscopic Roux-en-Y Gastric Bypass Versus Laparoscopic Sleeve Gastrectomy to Treat Morbid Obesity-Related Comorbidities: a Systematic Review and Meta-analysis. *Obes Surg* 2016, 26(2):429-442.
8. Panunzi S, De Gaetano A, Carnicelli A, Mingrone G: Predictors of remission of diabetes mellitus in severely obese individuals undergoing bariatric surgery: do BMI or procedure choice matter? A meta-analysis. *Ann Surg* 2015, 261(3):459-467.
9. Shoar S, Saber AA: Long-term and midterm outcomes of laparoscopic sleeve gastrectomy versus Roux-en-Y gastric bypass: a systematic review and meta-analysis of comparative studies. *Surg Obes Relat Dis* 2017, 13(2):170-180.
10. Courcoulas AP, King WC, Belle SH, Berk P, Flum DR, Garcia L, Gourash W, Horlick M, Mitchell JE, Pomp A *et al*: Seven-Year Weight Trajectories and Health Outcomes in the Longitudinal Assessment of Bariatric Surgery (LABS) Study. *JAMA Surg* 2018, 153(5):427-434.
11. de Toro-Martin J, Guenard F, Tchernof A, Perusse L, Marceau S, Vohl MC: Polygenic risk score for predicting weight loss after bariatric surgery. *JCI Insight* 2018, 3(17).
12. Aasbrenn M, Schnurr TM, Have CT, Svendstrup M, Hansen DL, Worm D, Balslev-Harder M, Hollensted M, Grarup N, Burgdorf KS *et al*: Genetic Determinants of Weight Loss After Bariatric Surgery. *Obes Surg* 2019.

13. Shilton H, Gao Y, Nerlekar N, Evennett N, Ram R, Beban G: Pre-operative Bariatric Clinic Attendance Is a Predictor of Post-operative Clinic Attendance and Weight Loss Outcomes. *Obes Surg* 2019, 29(7):2270-2275.
14. Aminian A, Daigle CR, Romero-Talamas H, Kashyap SR, Kirwan JP, Brethauer SA, Schauer PR: Risk prediction of complications of metabolic syndrome before and 6 years after gastric bypass. *Surg Obes Relat Dis* 2014, 10(4):576-582.
15. Rishi L, Bhandari M, Kumar R: Can bariatric surgery delay the need for knee replacement in morbidly obese osteoarthritis patients. *J Minim Access Surg* 2018, 14(1):13-17.
16. Cazzo E, Pareja JC, Chaim EA: Nonalcoholic fatty liver disease and bariatric surgery: a comprehensive review. *Sao Paulo Med J* 2017, 135(3):277-295.
17. Binda A, Jaworski P, Kudlicka E, Ciesielski A, Cabaj H, Tarnowski W: The impact of selected factors on parameters of weight loss after sleeve gastrectomy. *Wideochir Inne Tech Maloinwazyjne* 2016, 11(4):288-294.
18. Schwoerer A, Kasten K, Celio A, Pories W, Spaniolas K: The effect of close postoperative follow-up on co-morbidity improvement after bariatric surgery. *Surg Obes Relat Dis* 2017, 13(8):1347-1352.
19. Jurgensen JA, Reidt W, Kellogg T, Mundi M, Shah M, Collazo Clavell ML: Impact of Patient Attrition from Bariatric Surgery Practice on Clinical Outcomes. *Obes Surg* 2019, 29(2):579-584.
20. CADTH: Guidelines for the economic evaluation of health technologies: Canada. In., 4th edn. Ottawa; 2017: 19.
21. Rosella LC, Lebenbaum M, Fitzpatrick T, O'Reilly D, Wang J, Booth GL, Stukel TA, Wodchis WP: Impact of diabetes on healthcare costs in a population-based cohort: a cost analysis. *Diabet Med* 2016, 33(3):395-403.
22. Weaver CG, Clement FM, Campbell NR, James MT, Klarenbach SW, Hemmelgarn BR, Tonelli M, McBrien KA, Alberta Kidney Disease N, the Interdisciplinary Chronic Disease C: Healthcare Costs Attributable to Hypertension: Canadian Population-Based Cohort Study. *Hypertension* 2015, 66(3):502-508.
23. Conly J, Clement F, Tonelli M, Hemmelgarn B, Klarenbach S, Lloyd A, McAlister FA, Husereau D, Wiebe N, Au F *et al*: Cost-effectiveness of the use of low- and high-potency statins in people at low cardiovascular risk. *CMAJ* 2011, 183(16):E1180-1188.

Tables

Table 1 Model parameters

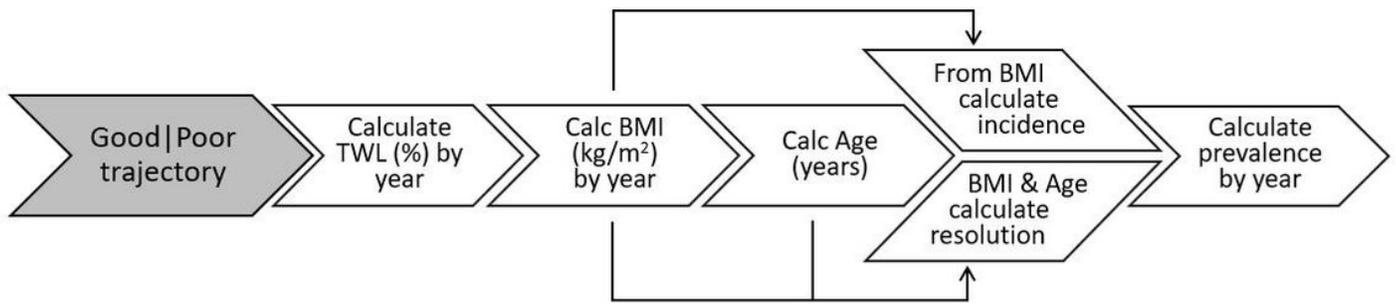
| Parameter | Reference | Base case | Notes |
|-----------------------|-------------------------|--|---|
| Age | Courcoulas 2018[10] | 45 ± 8.5 years | Use population demographics of entire RYGB surgery cohort (no trajectory group stratification) |
| BMI | | 46.6 ± 4.8 kg/m ² | |
| Female | | 79.9 % ± 1.0 % | |
| T2DM baseline | | 35.4 % ± 1.2 % | |
| HTN baseline | | 68.9 % ± 1.1 % | |
| High LDL baseline | | 36.6 % ± 1.1 % | |
| Cohort size | N/A | 100 patients | Example cohort |
| Discount rate | CADTH guidelines[20] | 1.5 % | 4 th edition guidelines of the Canadian Agency for Drugs and Technology in Health (CADTH) |
| Cost T2DM, year 1 | Rosella 2016[21] | Male: \$4,061 ± \$609 Female: \$4,017 ± \$603 | Ontario Base value uncertainty taken as ±15% |
| Cost T2DM, year 2+ | Rosella 2016[21] | Male: \$828 ± \$123 Female: \$1,023 ± \$124 | Ontario Base value average costs years 2-8 in study |
| Cost HTN | Weaver 2015[22] | \$2,163 ± \$227 | Canada wide |
| Cost Dyslipidaemia | Conly 2011[23] | \$79 ± \$8 | Alberta Final value includes only laboratory costs for patients on statins minus costs for patient time and travel |

Table 2 Ten-year cumulative results

| | Measurement | Result |
|---------------|---------------------------------------|---|
| T2DM | Patient years from cases not resolved | 58 [44; 70] |
| | Patient years from new onset | 123 [37; 199] |
| | Costs for non-resolved patients | \$52,488 [\$36,833; \$69,483] |
| | Costs for incident cases | \$176,872 [\$55,178; \$293,029] |
| | Total T2DM costs | \$229,686 [\$95,870; \$359,501] |
| HTN | Patient years from cases not resolved | 124 [97; 150] |
| | Patient years from new onset | 692 [267; 999] |
| | Costs for non-resolved patients | \$248,953 [\$177,556; \$326,926] |
| | Costs for incident cases | \$1,350,579 [\$509,218; \$2,094,299] |
| | Total HTN costs | \$1,596,388 [\$711,234; \$2,401,698] |
| Dyslipidaemia | Patient years from cases not resolved | 121 [97; 146] |
| | Patient years from new onset | 409 [131; 646] |
| | Costs for non-resolved patients | \$8,824 [\$6,496; \$11,590] |
| | Costs for incident cases | \$29,078 [\$9,064; \$48,879] |
| | Total dyslipidaemia costs | \$37,896 [\$15,883; \$60,499] |
| Public costs | | \$1,869,887 [\$823,832; \$2,777,124] |

Values shown are the additional treatment years or additional costs resulting from a 100-patient cohort achieving a poor, versus a good post-RYGB surgery weight trajectory. “Patient years” refer to cumulative years of patient treatment over the 10-year time horizon and costs are presented in 2018 Canadian dollars (\$). Total public costs are those expected to be taken on by public payers (hospitalization, physician, etc) and in the present analysis, exclude the dyslipidaemia cost, which are comprised primarily of medication. Overall total costs include all three co-morbidity costs (T2DM, HTN, dyslipidaemia). Values are reported with 95% credibility intervals determined from 10,000 iterations of sampling within model parameter uncertainties (base case). HTN, hypertension; T2DM, type 2 diabetes mellitus.

Figures



Sum over time horizon:

$$\text{Cumulative cases impact} = (\text{Ncases}_{\text{poor}} - \text{Ncases}_{\text{good}}) \cdot \text{year}$$

$$\text{Cumulative costs impact} = \text{Cumulative cases} \times \text{annual co-morbidity costs}$$

Figure 1

Scheme for analysis of outcome and cost impact by weight trajectory

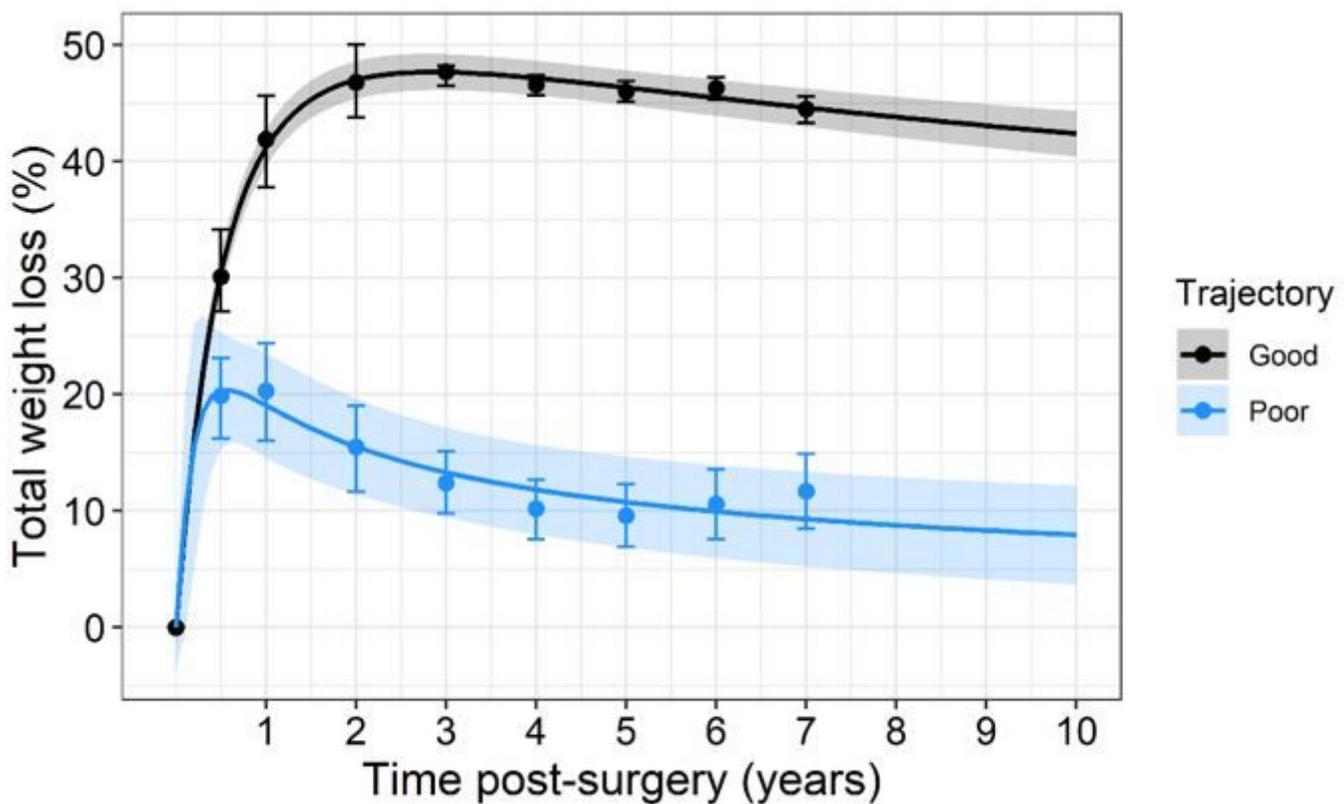


Figure 2

Modelling of post-surgical total weight loss

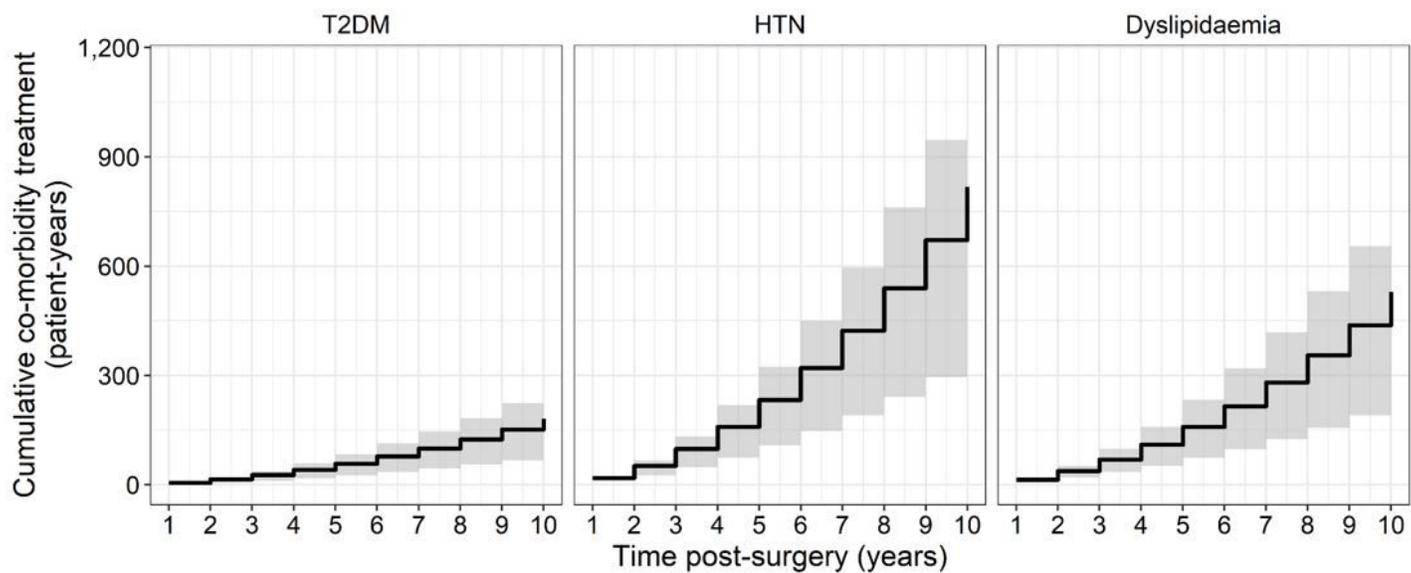


Figure 3

Comparison of cumulative patient-years of co-morbidity treatment after bariatric surgery