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Am I on Track? Evaluating Patient-Specific Weight Loss After Bariatric Surgery Using an Outcomes Calculator

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ORIGINAL CONTRIBUTIONS

Am I on Track? Evaluating Patient-Specific Weight Loss After Bariatric Surgery Using an Outcomes Calculator

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Abstract

Purpose Individual weight loss outcomes after bariatric surgery can vary considerably. As a result, identifying and assisting patients who are not on track to reach their weight loss goals can be challenging.

Materials and Methods Using a bariatric surgery outcomes calculator, which was formulated using a state-wide bariatric-specific data registry, predicted weight loss at 1 year after surgery was calculated on 658 patients who underwent bariatric surgery at 35 different bariatric surgery programs between 2015 and 2017. Patient characteristics, postoperative complications, and weight loss trajectories were compared between patients who met or exceeded their predicted weight loss calculation to those who did not based on observed to expected weight loss ratio (O:E) at 1 year after surgery.

Results Patients who did not meet their predicted weight loss at 1 year ($n = 237$, 36%) had a mean O:E of 0.71, while patients who met or exceeded their prediction ($n = 421$, 63%) had a mean O:E = 1.14. At 6 months, there was a significant difference in the percent of the total amount of predicted weight loss between the groups (88% of total predicted weight loss for those that met their 1-year prediction vs 66% for those who did not, $p < 0.0001$). Age, gender, procedure type, and risk-adjusted complication rates were similar between groups.

Conclusion Using a bariatric outcomes calculator can help set appropriate weight-loss expectations after surgery and also identify patients who may benefit from additional therapy prior to reaching their weight loss nadir.

Keywords Bariatric surgery · Weight loss outcomes diabetes · Patient-reported outcomes

Introduction

Although bariatric surgery is considered the most effective treatment for severe obesity, individual weight loss outcomes can vary considerably depending on patient-specific characteristics as well as procedure type [1–5]. Mean overall weight loss is often reported by procedure type as a percentage of total or excess body weight loss. However, such estimations fail to account for the known impact of race, age, and diabetes on weight loss and thus have limited utility when managing a diverse patient population [1, 3, 6, 7]. Moreover, weight loss outcomes are typically reported at 1 year after surgery and so the weight loss trajectory during the first year of surgery is unclear for any individual patient. As a result, counseling patients on whether they are on track to reach their weight loss target remains a challenge.

To address this issue, the Michigan Bariatric Surgery Collaborative (MBSC) developed a publicly available weight-loss outcome calculator named "Weigh the Odds" using a robust bariatric-specific data registry. The calculator, which can be found on Google Play® and the App Store®, utilizes over 30 variables to calculate individual weight loss outcomes as well as complication rates and comorbidity reduction at 1 year after surgery. Although this tool can be used

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to inform patients about weight loss expectations after surgery, predicted vs actual weight loss experienced by patients has yet to be compared. Furthermore, weight loss trajectories for patients who fall short of their calculated predicted weight loss does not exist.

To evaluate which patients fell off of their projected target weight loss, we plotted 1-year weight loss trajectories for patients undergoing primary laparoscopic sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) and compared patients who did and did not meet their calculated weight loss prediction using the outcomes calculator. Patient characteristics and percentage of total predicted weight loss achieved by month were used to identify at-risk patients and when they were most likely to deviate from their predicted outcome.

Methods

Data Source and Study Population

Data was obtained from the Michigan Bariatric Surgery Collaborative (MBSC), which uses a robust bariatric-specific data registry for collaborative quality improvement [8]. Hospitals participating in the MBSC (teaching and non-teaching) utilize a centrally trained data abstractor to submit perioperative data from the medical record and include a wide range of information on patient demographics, comorbid conditions, and postoperative outcomes. The MBSC also captures patient-reported outcomes (PROs) among patients who complete baseline and annual follow-up questionnaires. Program site visits are also performed annually by the coordinating center to ensure the accuracy and completeness of the data. For this study, we included all patients 18 years and older who underwent primary sleeve gastrectomy or Roux-en-Y gastric bypass (RYGB) at hospitals participating in the MBSC (n = 38) between June 2015 and October 2017, who also had a documented weight at on the day of surgery as well as at 1 year after surgery. In addition, all patients must have had greater than 3 postoperative weight measurements within the first year after their procedure (n = 658). The study was approved by the institutional review board for the MBSC.

Study Design and Data Collected

The MBSC "Weigh the Odds" app was used to calculate individual 1-year weight loss outcomes for all patients included in the study. Variables used to calculate a patient's predicted weight loss are included in Table 1 and associated with the MBSC data registry. The calculator is derived from a prediction model that includes 45,860 patients from the MBSC data registry from June 2006 to February 2019. Internal validation was performed using observed to expected ratio (O:E), calibrated curve, C-statistic, receiver operating characteristic (ROC), and Hosmer-Lemeshow test of good fit using 100% of the sample data. ROC data and a calibration curve from the model were provided by the MBSC for this study (Appendix Figure 2). A patient's starting weight was defined as the weight obtained on the day of surgery and their final weight was obtained at their 1-year follow-up visit. An observed to expected weight loss ratio (O:E) was calculated using the predicted weight calculated by the MBSC weight loss calculator and actual weight at 1 year after surgery. Patients were then grouped into those that met or exceeded their predicted weight loss (O:E ≥ 1) and those who did not (O:E < 1). Preoperative characteristics, procedure type, 30-day risk-adjusted complication rates, and total body weight loss (TBWL)% at 1 year

Table 1 Variables included in the weight-loss calculator

Variable
Procedure type
- LAGB — laparoscopic adjustable gastric banding
- LRYGB — laparoscopic Roux-en-Y gastric bypass
- ORYGB — open Roux-en-Y gastric bypass
- LSG — laparoscopic sleeve gastrectomy
- BPD/DS — biliopancreatic diversion with duodenal switch
Demographics
- Weight
- Height
- Private insurance (yes/no)
- Age
- Gender
- Race
Comorbidities
- Gastroesophageal reflux disease
- Hernia
- Liver disorder
- Hyperlipidemia
- Urinary incontinence
- Cholelithiasis
- Peptic ulcer disease
- Psychological disorder
- Sleep apnea
- Renal function disorder
- Musculoskeletal disorder
- Peripheral vascular disease
- Heart rhythm disorder
- Chronic heart failure
- Hypertension
- Coronary artery disease
- Chronic obstructive pulmonary disease
- Asthma
- Utilization of home oxygen
- Insulin dependent diabetes
- Non-insulin dependent diabetes
Other risk factors
- Use of mobility aids
- History of venous thromboembolism
- History of smoking

were compared between groups. Mean overall percent of predicted weight loss achieved monthly was also compared between groups.

Data on patient characteristics included age, mean preoperative body mass index (BMI), sex, race, married/living with significant other, education, employment, income, and type of insurance. Preoperative comorbidities included hypertension, hyperlipidemia, diabetes (insulin dependent and non-insulin dependent), psychological disorder (i.e., anxiety, depression, and bipolar disease), musculoskeletal disorder (i.e., arthritis), gastroesophageal reflux disease (GERD), asthma, obstructive sleep apnea (OSA), coronary artery disease (CAD), cardiovascular disease (CVD), history of smoking at the time of initial evaluation, and history of venous thromboembolism (VTE). Medical and surgical complications were captured on all patients within 30 days of surgery. Surgical complications included infection (surgical site, wound, abdominal abscess), leak, stricture, bowel obstruction, and bleeding requiring blood transfusion, reoperation, or splenectomy. Medical complications included pneumonia, respiratory failure, renal failure, VTE, myocardial infection, cardiac arrest, shock, and death. Serious complications were defined as bowel obstruction, leak, abdominal abscess, wound complication, dehiscence, hemorrhage, venous thromboembolism, myocardial infarction, renal failure, pneumonia, reintubation, prolonged ventilator use, shock, hospital-acquired infections, and death.

Statistical Analysis

Comparisons of baseline patient characteristics, comorbidities, and surgery type between the two groups (O:E ≥ 1 vs O:E < 1) were performed using Fisher's exact test for binary factors (e.g., gender, race: white, and race: black) and independent samples *t*-tests for continuous variables (e.g., age and weight outcomes). One variable, number of days between initial consult and surgical dates, was compared using a Wilcoxon rank sum test since the data for this variable did not conform to the assumption of normality that is required for *t*-test comparisons.

We compared 30-day complication rates and TBWL% at 1 year using multivariable logistic and linear regression models, respectively, adjusting for patient preoperative characteristics, comorbidities, and procedure type.

Results

A total of 658 patients were included in the study, which provided 3866 data points for weight. Among these patients, 17.3% underwent RYGB and 82.7% underwent sleeve gastrectomy. Mean overall O:E for patients in the study was 1.13. Patients who did not meet their predicted weight loss calculation (O:E < 1, $n = 237$) had a mean O:E of 0.71 at 1 year after surgery, while patients who either met or exceeded their predicted weight loss calculation (O:E ≥ 1, $n = 421$) had a mean O:E of 1.14. Patient characteristics, procedure type, and weight loss outcomes are compared between groups (O:E ≥ 1 vs O:E < 1) in Table 2. Patients with an O:E < 1 had a lower mean preoperative BMI (46.7 kg/m^2 vs 48.5 kg/m^2, $p = 0.079$), were more likely to be Black (13.9% vs 8.2%, $p = 0.023$), and had higher rates of hypertension (59.1% vs 48.9%, $p = 0.0124$), coronary artery disease (10.6% vs 5.7%, $p = 0.0230$), cardiovascular disease (62% vs 52.5%, $p = 0.0181$), and were more likely to have a smoking history at their initial consultation (11% vs 6.4%, $p = 0.0392$) when compared to patients with an O:E ≥ 1. Age, sex, procedure type, and complication rates were not associated with reaching individual weight-loss predictions. Patients who did not meet their predicted weight loss calculation had a mean total body weight loss percentage that was lower than those who did (20.2% vs 29%, $p < 0.0001$). Fig. 1 and Table 3 compare monthly mean % of predicted weight loss achieved between patients who met or exceeded their predicted weight loss at 1 year (O:E ≥ 1.0) to those who did not (O:E < 1). Significant differences in weight loss trajectories can be identified as early as 3 months after surgery as those who met their 1 year target had already achieved 58% of their individually calculated 1-year weight loss prediction, while patients who did not meet their target had only achieved 50% of total predicted weight loss amount ($p < 0.0001$). By 6 months, all patients who achieved less than 66% of their total weight loss prediction failed to meet their calculated target at 1 year.

Discussion

In this novel evaluation of weight loss trajectories after bariatric surgery, we utilized a weight loss outcomes calculator to compare predicted vs actual weight loss at 1 year after surgery. By comparing observed to expected weight loss, we found that patients who did not meet at least 66% of their total predicted weight loss by 6 months, ultimately, did not meet their calculated projection for weight loss at 1 year, which serves as simple clinical guide for patients and clinicians as the "Rule of 6s." Given the known variation in weight loss outcomes by procedure type and also the impact of age, race, and comorbidities, this study is vital in helping to understand outcomes of bariatric surgery within a diverse population and also provides useful data to help manage expectations for patients and clinicians alike. In addition, this data can be used to identify specific patients who are unlikely to reach their target weight loss and who may benefit from additional therapies in the first year after surgery.

Prior studies involving predictive weight loss algorithms have been limited to a small number of variables that affect weight loss outcomes and only included single surgeon or

Table 2 Comparison of demographics, preoperative comorbidities, procedure type, and 30-day risk-adjusted complication rates among patients that met or exceeded their calculated predicted weight loss O:E ≥ 1 and those that did not O:E < 1 (*O:E*, observed to expected ratio; *BMI*, body mass index; *SD*, standard deviation)

	Overall (n = 658)	O:E ≥ 1 (n = 421)	O:E < 1 (n = 237)	p-value
Demographics				
Mean age, years (SD)	47.6 (11.9)	47.0 (12.3)	48.7 (11.2)	0.0837
Mean preoperative BMI, kg/m^2 (SD)	47.8 (8.4)	48.5 (8.4)	46.7 (8.2)	0.0079
Female, %	83.6	84.1	82.7	0.6452
Male, %	16.4	15.9	17.3	
White race, %	80.6	82.7	77.1	0.0849
Black race, %	10.2	8.2	13.9	0.0230
Married/living with significant other, %	64.1	64.2	64.1	0.9874
At least some college, %	81.4	82.6	79.3	0.3078
Working full-/part-time, %	64.4	64.9	63.5	0.7266
Income, %				
< $25,000	24.7	24.5	25	0.8898
$25,000 to $44,999	20.6	20.3	21.1	0.8215
$45,000 to $74,999	26.9	29.2	22.8	0.0814
≥ $75,000	27.9	26.0	31.1	0.1645
Private insurance, %	72.0	73.2	70	0.3924
Medicare, %	15.8	14.3	18.6	0.1454
Medicaid, %	9.1	10	8.4	0.6495
Self-pay/no insurance, %	3.00	3.1	3.0	0.9233
Preoperative comorbidities				
Hypertension, %	52.6	48.9	59.1	0.0124
Hyperlipidemia, %	52	49.9	55.7	0.1518
Diabetes, %	37.1	35.40	40.1	0.2316
Psychological disorder, %	58.8	59.1	58.2	0.8185
Musculoskeletal disorder, %	74.5	75.3	73	0.5158
GERD, %	54.3	52.5	57.4	0.2268
Asthma, %	22.6	23.3	21.5	0.6048
Sleep apnea, %	48.6	48.5	49	0.9041
Coronary artery disease, %	7.5	5.7	10.6	0.0230
Cardiovascular disease, %	55.9	52.5	62	0.0181
Smoker at initial visit, %	8.1	6.4	11	0.0392
History of venous thromboembolism, %	3.7	3.3	4.2	0.5570
Procedure type				
Roux-en-Y gastric bypass, %	17.3	15.7	20.3	0.1365
Sleeve gastrectomy, %	82.7	84.3	79.8	
1 year weight loss				
Mean total body weight loss, lbs (SD)	88.6 (36.4)	104.8 (32.8)	59.6 (21.6)	< 0.0001
Mean total body weight loss, % (SD)	26.1 (9.1)	29.2 (8.5)	20.2 (6.4)	< 0.0001
30 day risk-adjusted complications				
Any complication, %	6.2	6.2	6.3	0.8752
Serious complication, %	1.5	1.4	1.7	0.8047

single center data that involved gastric bypass alone [6, 7, 9, 10]. While most studies considered variables such as age, sex, height, weight, and BMI when generating predictive models, Wise et al. and Wood et al. also included factors such as race, preoperative hemoglobin, and preoperative comorbidities such as diabetes, depression, and anxiety disorder [6, 10]. Reported weight loss outcomes for prediction models spanned from 1 to 5 years, but follow-up rates tended to be poor after the first year. More recently, the American College of Surgeons/Metabolic and Bariatric Surgery Accreditation and

Table 3 Comparison of monthly mean percent of total predicted weight loss achieved between patients who met or exceeded their predicted weight loss O:E ≥ 1 and those who did not O:E < 1 (*SD*, standard deviation)

# of months after surgery	O:E ≥ 1		O:E < 1		*p*-value
	% of predicted weight loss (SD)	Weight loss data points (*n*)	% of predicted weight loss (SD)	Weight loss data points (*n*)	
1	31 (10)	370	30 (12)	207	0.2256
2	43 (16)	138	43 (16)	69	0.9682
3	58 (16)	242	50 (16)	123	< 0.0001
4	71 (16)	145	54 (14)	79	< 0.0001
5	81 (17)	56	61 (20)	30	< 0.0001
6	88 (19)	246	66 (18)	140	< 0.0001
7	93 (21)	86	66 (17)	43	< 0.0001
8	104 (22)	88	71 (21)	48	< 0.0001
9	107 (26)	98	69 (16)	54	< 0.0001
10	112 (23)	55	76 (21)	34	< 0.0001
11	108 (28)	31	68 (24)	23	< 0.0001
12	114 (27)	360	71 (24)	194	< 0.0001

Quality Improvement Program (ACS/MBSAQIP) created a web-based Bariatric Surgical Risk/Benefit Generator using 25 different variables, including multiple procedures and reports outcomes including weight loss at 1 year. Although we are not aware of any published reports using this calculator to date, it represents a similar use of a robust bariatric-specific data registry that includes thousands of patients undergoing surgery at a variety of bariatric surgery programs (academic and private practice).

Regardless of the weight-loss prediction model, it is clear that general reporting and comparing of weight loss outcomes after bariatric surgery suffers from a lack of clear definition for individual "success" and "failure" [11–13]. This is of particular importance because a lack of clarity may result in a misconception of the perceived effectiveness of bariatric surgery by patients, clinicians, and payers alike, further impacting referral and access to care. In addition, a misalignment of expectations regarding weight loss after bariatric surgery has an impact on patient satisfaction and psychological disposition if labeled as a "failure" [14]. Furthermore, since obesity remains a widespread disease that affects a diverse patient population, it is imperative to stratify outcomes appropriately so that patients can better gauge their individual risks and benefits of surgery before pursuing operative intervention. Our study not only accounts for the impact of procedure type, age, sex, race, and preoperative comorbid conditions on weight loss outcomes but it also offers a means to track progress within the first year of surgery.

In our study, we found that patients who experienced less than predicted weight loss tended to have a lower preoperative BMI, were more likely to be Black, and have higher rates of cardiac-related disease. Our findings may have been a result of the low volume of Black patients in our study cohort (10%) or unaccounted variables that may relate to variation in degree of disease severity, disparities in care or resources, or dedication to lifestyle interventions such as diet and exercise. Racial variation in outcomes among propensity matched patients have been reported by the MBSC in the past, which highlights biologic or genetic reasons for differences in weight loss outcomes [7]. Patients with higher rates of cardiac disease may have had limited exercise tolerance or were more likely to have their weight affected by edema or lack of appropriate diuresis, which could have impacted their overall weight loss outcome. Interestingly, higher rates of cardiac disease may have increased the risk for perioperative complications, which could have also affected weight loss; however, we did not find that to be the case as complication rates were similar between the groups. In addition, case distribution based on procedure type was not significantly different between groups, indicating that assessing weight loss trajectories based on individually calculated predicted target can be agnostic to procedure type.

Patient-specific weight loss trajectories based on calculated prediction models can help identify at-risk patients who may not achieve maximal weight loss within the first year of surgery. Early postoperative weight loss trajectory has been associated with predicting who achieves maximal weight loss after bariatric surgery [15–17]. Mor et al. were among the first to recognize that weight loss performance in the early period after gastric bypass was a significant predictor of long-term outcomes and that tracking weight loss outcomes can help identify underperformers early so that they may potentially improve their outcomes using addition therapies [16].

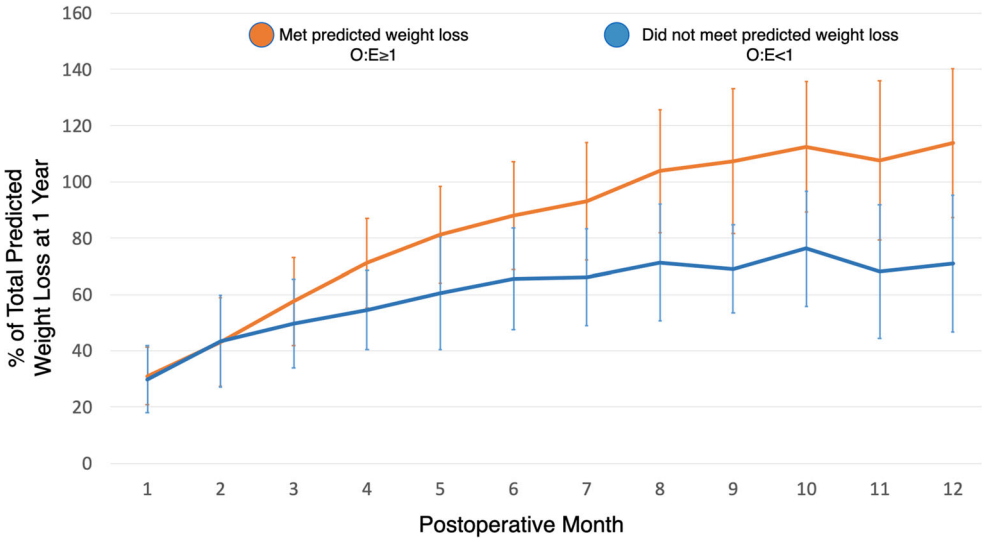

Fig. 1 Monthly mean percent of total predicted weight loss achieved among patients who met or exceeded their predicted weight loss O:E ≥ 1 and those who did not O:E < 1

Similarly, in an evaluation of weight loss outcomes after RYGB, Ritz et al. found that patients who lost < 30% of their initial excess weight at 6 months were unlikely to have lost ≥ 50% at 24 months [17]. Our study not only demonstrates a similar theme but also recognizes that "successful" weight loss outcomes can vary depending on multiple factors, which are accounted for using a predictive calculator. Although we agree that early identification of at-risk patients can help patients get "back on track" to achieving their individual projected weight loss goal, there is no standard protocol for type or timing of intervention in this regard. Our data support identifying and intervening on at-risk patients using a weight loss outcomes calculator and tracking percentage of total predicted weight loss achieved. Patients who fail to reach 66% of their total predicted weight loss calculation at 6 months ("Rule of 6s") can be subject to a multidisciplinary intervention that includes dietary, behavioral, and pharmacologic options.

Our study has several notable limitations. The first is that we utilized an outcomes calculator based on a state-wide data registry, which may not be applicable to other states or countries, particularly if demographics or race are vastly different. Although the MBSC prediction model underwent rigorous internal validation tests, it did not undergo external validation during the study period. As such, it is currently being tested using a data registry from a different country. Nevertheless, we believe that the value of this study is in using patient-specific outcomes as opposed to fixed arbitrary end points, which may overestimate or underestimate outcomes within a diverse patient population. As such, we chose to use a prediction model based on historical data from patients within our state so that their weight loss outcomes would be more representative of our own study population. The second limitation to our study is that it is unclear which patients were actively involved in medically supervised weight-loss program prior to surgery and whether this had any impact on final weight loss outcomes. However, we suspect that such programs, which are mandated by insurance, did not influence weight loss trajectories as the distribution of private insurance, Medicare, and Medicaid was similar between the groups. Finally, our study is limited to outcomes at 1 year, so the applicability of our findings on long-term outcomes is unknown. Of note, the MBSC weight loss calculator does include predicted weight loss calculations for a longer period of time (up to 3 years after surgery); however, our goal was to capture as many weight measurements per patient as possible, in order to trend mean monthly weight loss. As such, we were limited to tracking monthly weight loss in the first year, since most bariatric surgery programs have longer follow-up intervals (i.e., yearly), after the first year. In addition, we choose to evaluate outcomes at 1 year because maximal weight loss tends to plateau after this timeframe, which is a finding noted by numerous studies evaluating long-term weight loss outcomes after bariatric surgery [18–21]. Nevertheless, it would be interesting to evaluate whether 1-year weight loss predictions can also predict long-term weight loss outcomes and is the subject of future work.

Conclusions

Using a weight loss calculator can help predict individual weight loss outcomes, which may be useful when discussing goals and expectations after bariatric surgery. In addition, it is possible to identify patients who will not reach their predicted weight loss target by tracking the percentage of the predicted weight loss in the first year after surgery. We found that patients who did not reach 66% of their predicted weight loss calculation by 6 months did not reach their target weight loss at 1 year. At-risk patients may be considered for additional

interventions to help them get back on track and achieve their intended weight loss potential.

Appendix

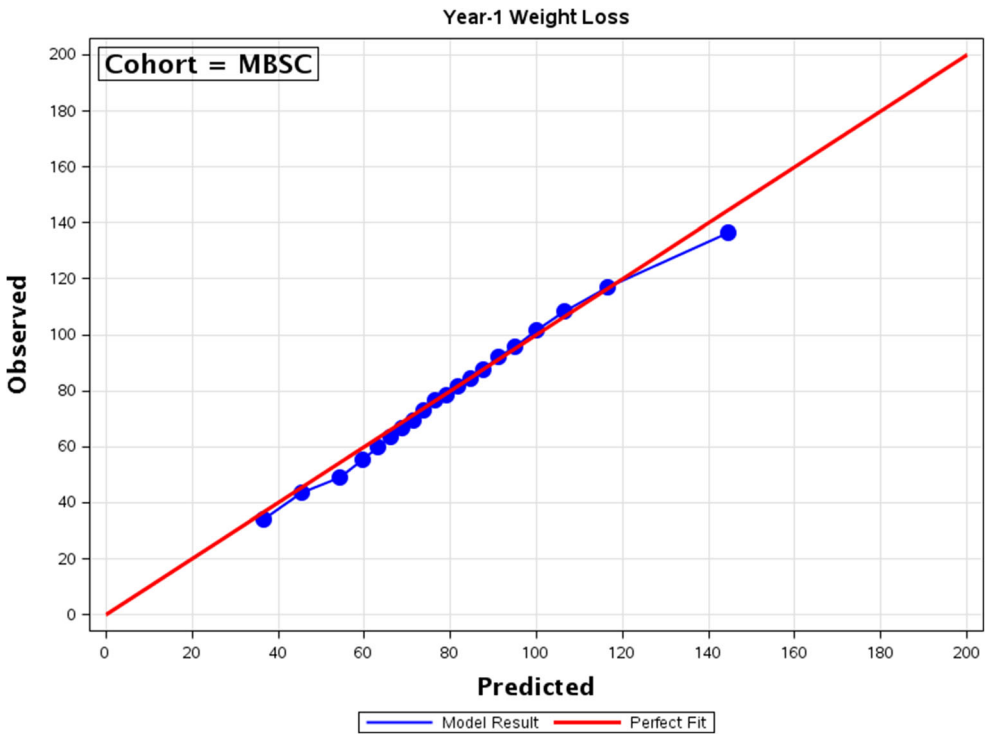

Fig. 2 Calibration curve demonstrating averages for each 5th percentile of weight loss

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Declarations

Ethical Approval Statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Statement Informed consent was obtained from all individual participants included in the study.

Conflict of Interest Oliver A. Varban reports other from Blue Cross Blue Shield of Michigan, during the conduct of the study. Aaron J. Bonham has nothing to disclose. Amanda L. Stricklen has nothing to disclose. Rachel Ross has nothing to disclose. Arthur M. Carlin reports other from Blue Cross Blue Shield of Michigan, during the conduct of the study. Jonathan F. Finks reports other from Blue Cross Blue Shield of Michigan, during the conduct of the study. Amir A. Ghaferi reports grants from AHRQ, grants from PCORI, and grants from Blue Cross Blue Shield of Michigan, outside the submitted work.

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