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Characterization of trends in preoperative hemoglobin A1c testing prior to metabolic and bariatric surgery: a retrospective, observational study

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Abstract

Background Irrespective of baseline diabetes status, preoperative hemoglobin A1c (A1C) influences perioperative care in patients undergoing metabolic and bariatric surgery (MBS). Accordingly, the American Society of Metabolic and Bariatric Surgery (ASMBS) endorses that patients undergoing MBS should receive a preoperative A1C test. We aimed to assess the proportion of MBS patients who received a preoperative A1C test and determine whether baseline diabetes status influences receipt of a test.

Methods We queried the 2017 to 2022 MBSAQIP database for patients undergoing open, laparoscopic, or robotic Roux-en-Y gastric bypass (RYGB) or sleeve gastrectomy. Using descriptive methods, we compared the clinical and demographic characteristics of patients who received a preoperative A1C test with patients who did not. We performed logistic regression analysis using diabetes status as a predictor variable and receipt of a test as the outcome, covarying for sociodemographic and clinical factors.

Results We identified 996,217 patients who underwent RYGB or sleeve gastrectomy between 2017 to 2022. The average age of the cohort was 43.8 years (SD = 11.9) and 81.0% were female. Overall, 45.7% received a preoperative A1C test. The proportion who was tested increased over the six-year study period, from 35.5% in 2017 to 56.0% in 2022. Compared to those who were not tested, patients who were tested were more likely to have several cardiopulmonary comorbidities, including COPD (1.4% vs 1.2%, $p < 0.001$), PE (1.4% vs 1.2%, $p < 0.001$), sleep apnea (39.3 vs. 36.4%, $p < 0.001$), HTN (47.1% vs 44.0%, $p < 0.001$), and MI (1.2% vs. 1.0%, $p < 0.001$), though the differences in proportions were small and may not be clinically significant. Compared to patients who did not have diabetes or had diabetes controlled by diet alone, patients with non-insulin dependent diabetes had 77% increased odds of receiving a A1C test (adjusted OR (aOR) 1.77, $p < 0.001$); insulin dependent patients had 113% increased odds (aOR 2.13, $p < 0.001$).

Conclusion Despite society recommendations endorsing measurement of preoperative A1C prior to MBS, less than half of patients undergoing MBS between 2017 and 2022 received a preoperative A1C test. Additionally, there were differential patterns in testing based on diabetes status. Preoperative glycemic evaluation is an area for continued quality improvement.

Keywords Hemoglobin A1c, Preoperative testing, Metabolic and bariatric surgery, Quality improvement

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Background

Metabolic and bariatric surgery (MBS) effectively treats obesity and its associated complications (Chang et al. 2014). Its safety rests on careful patient evaluation and clinical optimization (Benalcazar and Cascella 2022). Accordingly, a multi-disciplinary team will counsel patients on smoking cessation, evaluate nutritional status, and assess exercise and psychosocial functioning, among other practices, prior to surgery.

One focus of patient selection and optimization is glycemic evaluation. Although studies have demonstrated that there is no hemoglobin A1c (A1C) value above which MBS should be prohibitive, baseline A1C testing remains a critical part of the preoperative evaluation for all patients (Basishvili et al. 2021; Perna et al. 2012; Rawlins et al. 2013; Wysocki et al. 2019). For the 20–40% of patients with already diagnosed diabetes, preoperative A1C informs the need for additional medical optimization prior to surgery and, for those without baseline diabetes, A1C screens for prediabetes and diabetes, diagnosis of which influences perioperative care (Kumar et al. 2018; Garber et al. 2020). In response to variability in surgeon and institutional policy regarding preoperative glycemic evaluation, the American Society for Metabolic and Bariatric Surgery (ASMBS) published clinical practice guidelines where they endorse the measurement of preoperative A1C as part of patient evaluation (Mechanick et al. 2019; Carter et al. 2021).

To improve safety, there has been increasing interest in evaluating frequency of screening practices and patient evaluations prior to MBS. For example, recent analyses have highlighted areas for quality improvement by identifying deficiencies in substance abuse screening and nutritional status evaluation (Jatana et al. 2023; Gudzune et al. 2013). No study has evaluated the practice of preoperative A1C testing. Accordingly, we aimed to use the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database to assess the proportion of MBS patients who undergo A1C testing and determine whether measurement of A1C is influenced by baseline diabetes status. Through this analysis, we hope to highlight opportunities for quality improvement surrounding preoperative patient evaluation.

Materials and methods

Study design and data source

We conducted an observational cross-sectional study by retrospectively reviewing the MBSAQIP database from 2017 to 2022. The MBSAQIP is the largest, bariatric specific dataset in North America, containing prospectively collected data from accredited inpatient and outpatient centers in the United States and Canada (American College of Surgeons 2022). Preoperative patient demographics and comorbidities, intraoperative and postoperative variables, laboratory values, and 30-day morbidity outcomes are collected at each center by trained Metabolic and Bariatric Surgical Clinical Reviewers (MBSCRs) (American College of Surgeons 2022). We chose 2017 as our initial year of analysis as it was the first year the MBSAQIP collected data on preoperative A1C. We reported our analysis according to The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Study cohort

We included cases from 2017 to 2022 that were coded as either primary sleeve gastrectomy by Current Procedural Terminology (CPT) codes 43775 and 43842 or primary Roux-en-Y gastric bypass (RYGB) by CPT codes 43644, 43645, 43846, and 43847. We included cases where the approach was categorized as open, laparoscopic, or robotic assisted. We excluded endoscopic based procedures. We did not restrict our cohort based on age or preoperative body mass index (BMI).

Study variables

Our primary outcome of interest was receipt of a preoperative A1C test, which we identified using the MBSAQIP variable "HEMO" where a documented value indicated performance of a test. Sociodemographic variables of interest included patient age, sex, race/ethnicity, and procedure year. Clinical variables examined included preoperative BMI, functional status, smoking status, and American Society of Anesthesiologists (ASA) class. We also assessed whether or not patients had a history of diabetes, chronic obstructive pulmonary disease (COPD), pulmonary embolism (PE), sleep apnea, gastroesophageal reflux disease (GERD), myocardial infarction (MI), primary coronary intervention (PCI)/percutaneous transluminal coronary angioplasty (PTCA), cardiac surgery, hypertension (HTN), hyperlipidemia (HLD), deep vein thrombosis (DVT), renal insufficiency, dialysis, inferior vena cava (IVC) filter placement, and anticoagulation therapy. All variables were defined based on the MBSAQIP participant user file (American College of Surgeons 2022).

Statistical analysis

For continuous sociodemographic and clinical variables, we reported mean with standard deviations (SD) or median with interquartile ranges (IQR). For categorical variables, we reported counts and percentages. We performed t-tests and chi-square tests when comparing continuous and categorical data, respectively. We constructed a multivariable logistic regression model to evaluate the association between diabetes status (predictor variable) and receipt of an A1C test (outcome). Diabetes status was a categorical variable with the following levels as defined by MBSAQIP: (1) no diabetes/diabetes controlled by diet, (2) non-insulin dependent, and (3) insulin dependent. "No diabetes/diabetes controlled by diet" was chosen as the reference group. We adjusted for patient age, sex, race/ethnicity, procedure year, preoperative BMI, and surgery type. Additionally, to account for patient baseline physical status, we adjusted for ASA class. All covariates were categorical variables except for age which was continuous. We estimated variances in the regression model using the Huber/White sandwich estimator, which is robust to certain types of model misspecification. We reported regression coefficients as adjusted odds ratios (aOR) with 95% confidence intervals. All statistical analyses were performed using Stata 18.0 MP (StataCorp, College Station, TX).

Institutional review board

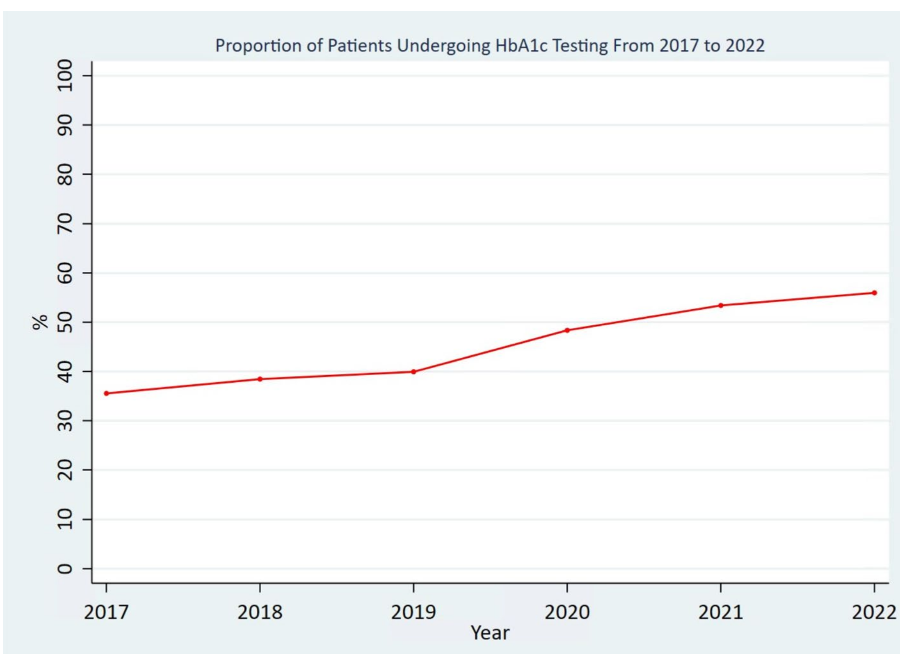
The Yale Human Investigation Committee determined that this study did not constitute human participants research and did not require institutional review board approval.

Results

In total, 996,217 patients underwent primary RYGB ($N = 264{,}214$, 26.52%) or sleeve gastrectomy ($N = 732{,}003$, 73.48%) between 2017 and 2022. The patients were, on average, 43.8 years (SD = 11.9 years, range 10–80) and 807,014 (81.0%) were female. Overall, 62.2% of patients were non-Hispanic White, 20.7% were non-Hispanic Black, 16.0% were Hispanic, and 1.1% were classified as another race. The median preoperative BMI overall was 44 (IQR = 9).

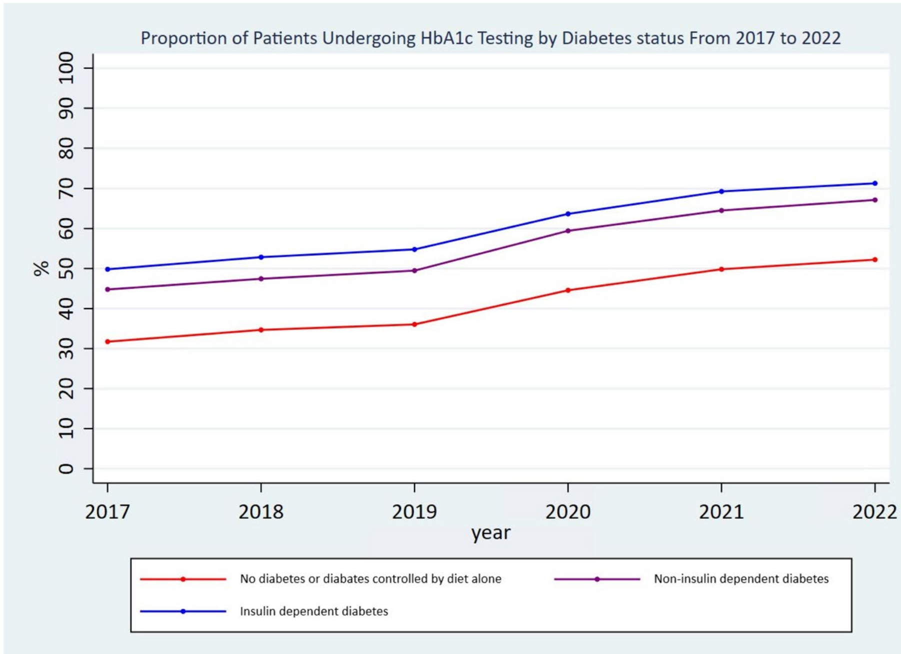
Across the entire six year study period, 45.7% of patients received an A1C test. The median number of days from receipt of an A1C test to surgery was 20 (IQR = 50). The proportion of patients with an A1C test progressively increased each year; 35.5% were tested in 2017, 38.4% in 2018, 39.9% in 2019, 48.4% in 2020, 53.4% in 2021, and 56.0% in 2022 (Fig. 1). When the cohort was stratified by diabetes status, at each year of analysis, patients with insulin dependent and non-insulin dependent diabetes were tested more frequently than those without diabetes or who had diabetes controlled by diet alone (Fig. 2).

Our bivariate analyses were all statistically significant ($p < 0.001$) due to our large sample size, but they are likely not clinically significant. For this reason, we do not report p-values from our Chi-square and t-tests in Table 1. Overall, patients who received a test were of similar age to those who did not receive a test (tested: mean = 44.0 years, SD = 11.9; not tested: mean = 43.6 years, SD = 11.9) (Table 1). There were proportionally more patients with an A1C test who had either a history of non-insulin dependent (21.1% vs



HbA1c = hemoglobin A1c

Fig. 1 Proportion of patients undergoing A1C testing from 2017 to 2022. HbA1c = hemoglobin A1c



HbA1c = hemoglobin A1c

Fig. 2 Proportion of patients undergoing A1C testing by diabetes status from 2017 to 2022. HbA1c = hemoglobin A1c

14.1%) or insulin dependent diabetes (9.3% vs 5.3%) compared to patients without an A1C test. Compared to those who were not tested, patients who were tested had proportionally more cardiopulmonary comorbidities, including COPD (1.4% vs 1.2%), PE (1.4% vs 1.2%), sleep apnea (39.3 vs. 36.4%), HTN (47.1% vs 44.0%), and MI (1.2% vs. 1.0%) (Table 1). On regression analysis, compared to patients who did not have diabetes or had diabetes controlled by diet alone, patients with non-insulin dependent diabetes had 77% increased odds of receiving an A1C test (aOR 1.77, $p < 0.001$) and insulin dependent patients had 113% increased odds (aOR 2.13, $p < 0.001$) (Table 2).

Discussion

The safety of MBS hinges on careful patient evaluation and optimization. Irrespective of baseline diabetes status, knowledge of patient A1C values prior to MBS influences perioperative care. Indeed, the ASMBS endorses that, while there is no A1C value above which surgery is prohibitive, patients undergoing MBS should receive an A1C test (Mechanick et al. 2019; Carter et al. 2021). Our study using six years of data from the MBSAQIP demonstrates that A1C testing has not yet become a universal practice. While the proportion of patients tested has steadily increased over time, until more recent years, less than half of patients undergoing MBS had their A1C measured preoperatively. Notably, there has been differential practice in which patients receive a test based on baseline diabetes status. As a whole, these results add to a body of literature assessing patient work up prior to MBS, but uniquely focus on glycemic evaluation (Jatana et al. 2023; Gudzune et al. 2013). In doing so, we highlight an area for quality improvement in the preoperative process.

Our findings with regard to glycemic evaluation prior to MBS exist in a broader landscape of challenges surrounding preoperative evaluation of surgical patients. Outside of bariatric surgery, practices of both under- and over-testing of surgical patients have been attributed to issues of uncertainty about who on the team is responsible for ordering tests as well as inability of clinicians to access/review patient records and consult/communicate with colleagues about preoperative decisions (Hall et al. 2022; Patey et al. 2012). Additionally, clinician concern about delaying surgery and the cost-effectiveness of testing have been cited as barriers to adequate evaluation (Hall et al. 2022; Patey et al. 2012). As MBS is the effort of a multi-disciplinary team involving surgeons, anesthesiologists, nurses, and other clinicians that often spans the course of several months, it is possible that many of these challenges extend to patient evaluation before bariatric surgery. To explore this, qualitative studies are needed to understand the individual, team, and organizational dogmas at bariatric programs that may impact the preoperative patient evaluation process.

Table 1 Baseline sociodemographic and clinical characteristics of patients

	A1C test					
	No		**Yes**		**Total**	
Number of patients, N (% of total patients)	541,009	(54.3)	455,208	(45.7)	996,217	(100.0)
Age, mean (SD)	43.6	(11.9)	44.0	(11.9)	43.8	(11.9)
Female, N (%)	441,861	(81.7)	365,153	(80.2)	807,014	(81.0)
Patient race, N (%)						
White	317,807	(63.2)	260,358	(61.0)	578,165	(62.2)
Black	104,573	(20.8)	88,280	(20.7)	192,853	(20.7)
Hispanic	75,363	(15.0)	73,359	(17.2)	148,722	(16.0)
Other	4,856	(1.0)	4,928	(1.2)	9,784	(1.1)
Pre-op BMI, median (IQR)	44	(9)	44	(9)	44	(9)
Days from A1C to surgery, median (IQR)	14	(38)	20	(50)	20	(50)
Pre-op functional status, N (%)						
Independent	536,919	(99.3)	451,804	(99.3)	988,723	(99.3)
Partially Dependent	2,678	(0.5)	2,518	(0.6)	5,196	(0.5)
Totally Dependent	1,120	(0.2)	461	(0.1)	1,581	(0.2)
Smoked within 1 year, N (%)	40,314	(7.5)	32,795	(7.2)	73,109	(7.3)
Type of Diabetes, N (%)						
None/diet alone	435,874	(80.6)	316,764	(69.6)	752,638	(75.5)
Non-Insulin dependent	76,343	(14.1)	96,010	(21.1)	172,353	(17.3)
Insulin dependent	28,792	(5.3)	42,434	(9.3)	71,226	(7.1)
History of COPD, N (%)	6,642	(1.2)	6,464	(1.4)	13,106	(1.3)
History of PE, N (%)	6,518	(1.2)	6,320	(1.4)	12,838	(1.3)
History of sleep apnea, N (%)	196,764	(36.4)	178,864	(39.3)	375,628	(37.7)
History of GERD, N (%)	161,536	(29.9)	137,230	(30.1)	298,766	(30.0)
History of MI, N (%)	5,181	(1.0)	5,673	(1.2)	10,854	(1.1)
History of PCI/PTCA, N (%)	7,468	(1.4)	7,640	(1.7)	15,108	(1.5)
History of cardiac surgery, N (%)	4,508	(0.8)	4,448	(1.0)	8,956	(0.9)
History of hypertension	238,085	(44.0)	214,262	(47.1)	452,347	(45.4)
History of hyperlipidemia	110,288	(20.4)	116,305	(25.5)	226,593	(22.7)
History of DVT	8,264	(1.5)	8,407	(1.8)	16,671	(1.7)
History of anticoagulation therapy, N (%)	14,672	(2.7)	14,228	(3.1)	28,900	(2.9)
History of IVC filter, N (%)	1,755	(0.3)	1,174	(0.3)	2,929	(0.3)
Dialysis (current or required), N (%)	1,655	(0.3)	1,554	(0.3)	3,209	(0.3)
History of renal insufficiency, N (%)	2,730	(0.5)	2,947	(0.6)	5,677	(0.6)
ASA Class						
ASA I	1,319	(0.2)	1,191	(0.3)	2,510	(0.3)
ASA II	110,156	(20.4)	84,002	(18.5)	194,158	(19.5)
ASA III	409,393	(75.9)	352,422	(77.5)	761,815	(76.7)
ASA IV	18,209	(3.4)	16,818	(3.7)	35,027	(3.5)
ASA V	44	(0.0)	53	(0.0)	97	(0.0)

A1C Hemoglobin A1c, *BMI* Body mass index, *COPD* Chronic obstructive pulmonary disease, *PE* Pulmonary embolism, *GERD* Gastroesophageal reflux disease, *MI* Myocardial infarction, *PCI/PTCA* Primary coronary intervention (PCI)/percutaneous transluminal coronary angioplasty, *DVT* Deep vein thrombosis, *IVC* Inferior vena cava, *ASA* American Society of Anesthesiologists

In our study, low prevalence of A1C testing may be attributable to a degree of measurement bias. It is possible that we are capturing inadequacies in reporting of A1C in the MBSAQIP database as opposed to deficiencies in preoperative evaluation. Indeed, large medical databases are fraught with issues of data completeness, a data quality metric that is often measured through frequency of missing data entries (Aziz et al. 2020; Yang et al. 2021). Interestingly, however, data quality in the MBSAQIP appears to be acceptable and consistent. In

Table 2 Summary of logistic regression output evaluating the association between diabetes status (predictor variable) and receipt of an A1C test (outcome), covarying for sociodemographic and clinical factors

	aOR	95% CI		p-value
Diabetes status				
No diabetes or diabetes controlled by diet	Reference			
Non-insulin dependent	1.77	1.75	1.79	< 0.001
Insulin dependent	2.13	2.10	2.17	< 0.001
Age	1.00	1.00	1.00	0.967
Procedure type				
RYGB	Reference			
Sleeve gastrectomy	0.90	0.89	0.91	< 0.001
Race/ethnicity				
White	Reference			
Black	1.00	0.99	1.01	0.616
Hispanic	1.13	1.12	1.15	< 0.001
Other	1.13	1.08	1.17	< 0.001
ASA class				
I	1.26	1.15	1.37	< 0.001
II	0.97	0.96	0.99	< 0.001
III	Reference			
IV	1.07	1.05	1.10	< 0.001
V	1.26	0.86	1.94	0.222

A1C Hemoglobin A1c, *RYGB* Roux-en-Y gastric bypass, *ASA* American Society of Anesthesiologists

a recent analysis, Clapp et al. studied the 2015 to 2019 MBSAQIP datasets and demonstrated that data were completed at a rate of over 97.5% with no significant differences across years (Clapp et al. 2024). The authors, however, only evaluated variables with mandatory reporting (i.e., age, race, ethnicity, BMI, ASA class, and preoperative weight) and acknowledged that laboratory values and other non-mandatory variables might have shown higher percentages of missing values. A better understanding of MBSAQIP data completeness will require analysis of non-mandatory variable collection which then would allow for contextualization of completeness of the A1C variable.

Nonetheless, the prevalence of A1C testing reported in our results is comparatively lower than that of other screening practices prior to MBS, many of which have also been assessed with non-mandatory MBSAQIP variables. The ASMBS and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO), for example, encourage screening for and optimization of substance abuse disorders and, in an analysis of the 2021 MBSAQIP database, Jatana et al. demonstrated that over 60% of patients received substance abuse screening (Jatana et al. 2023). Similarly, both societies recommend screening for cigarette smoking and, when appropriate, counseling on cessation. In a study of the 2015 to 2018 MBSAQIP datasets, approximately 90% of patients had a documented smoking status (Janik and Aryaie 2021). In a separate study examining associations between postoperative outcomes and preoperative albumin, a marker of nutritional status, over 70% of patients undergoing bariatric surgery had a registered preoperative albumin value in the 2015–2019 MBSAQIP databases (Hart et al. 2022). The comparatively higher prevalence of preoperative substance abuse, smoking, and nutrition evaluation evident in these studies underscores the opportunity for improvement when it comes to glycemic evaluation.

Although baseline comorbidities were largely comparable between those who were tested and those who were not, we found that patients with baseline diabetes had disproportionately higher odds of receiving an A1C test. In some ways, this may be an expected finding that reflects efforts to optimize those with a known risk for postoperative hyperglycemia. Although no clear association has been demonstrated between preoperative A1C and adverse outcomes after MBS, studies have demonstrated that preoperative A1C predicts early postoperative hyperglycemia, avoidance of which can improve outcomes after MBS (Basishvili et al. 2021; Perna et al. 2012; Rawlins et al. 2013; Wysocki et al. 2019). In this regard, knowledge of preoperative A1C values for those patients whose glycemic control is the most challenging at baseline (i.e., insulin-dependent patients) allows for the opportunity to adjust medications, consult medical specialists, and take other actions necessary to ensure perioperative glycemic optimization and favorable postoperative outcomes.

The concern, however, is that the benefits of testing those without a history of diabetes are being squandered. A subset of patients presenting for MBS are not diagnosed with prediabetes or diabetes until the time of preoperative A1C evaluation, a phenomenon likely related to general healthcare avoidance in the face of widespread obesity stigma (McGuigan and Wilkinson 2015; Mensinger et al. 2018). These patients can benefit from perioperative optimization in accordance with American Association of Clinical Endocrinology guidelines (Garber et al. 2020; Lee et al. 2020) and, for some, surgery may need to be delayed to optimize outcomes. An important consideration is that preoperative A1C testing may worsen the time and financial toxicity that many MBS patients experience (Ju et al. 2019; Alvarez et al. 2018). Since patients already present to clinics for standard preoperative lab work, A1C testing would likely not contribute substantially to the time burden of preoperative workup. Furthermore, many insurance policies include coverage of A1C testing prior to bariatric surgery (Gebran et al. 2020). For patients who are found to have elevated A1C levels, early glycemic control is associated with considerable reductions in healthcare costs (Lage and Boye 2020). Thus, regardless of baseline diabetes status, preoperative A1C values contribute to the individualized care plans of all patients and thus ensuring universal measurement can lead to earlier diagnosis and management of at risk patients.

While the frequency of testing was overall low, the proportion of patients receiving an A1C test did progressively increase each year from 35.5% in 2017 to 56.0% in 2022. Further studies will be needed to understand the reasons for this improvement, but possible explanations include better documentation, increased awareness of society guidelines, and changes to program-specific policy. Additionally, the inclusion of the "HEMO" variable in the MBSAQIP in 2017 could have been viewed by bariatric centers as a quality performance indicator. Performance indicators are powerful drivers of individual and organizational decisions in healthcare, a phenomenon summarized by the adage "what gets measured, gets done"(Goodreau 2007; Barbazza et al. 2021). As a result, the mere inclusion of the variable may have been an impetus for A1C testing.

Our study results should be interpreted in the context of key limitations. It is possible that A1C testing was completed at an external facility and not documented in the records of the hospital where the patient underwent surgery. The test result, therefore, would not have been available to the MBSCR to register into the database and, as a result, the MBSAQIP "HEMO" variable would underestimate the true A1C testing frequency. A retrospective chart review at the institution level is an alternative method that may have been able to capture these tests. Using the MBSAQIP database, however, allowed us to describe trends in preoperative A1C testing at the national level, which, in turn, can prompt more nuanced institution-specific reviews of current practice.

Additional study limitations are related to the data elements available in the MBSAQIP. Most comorbidities in the database are binary variables defined by either the absence or presence of the comorbidity. In this regard, we were unable to describe how patients who were tested and those who were not differed in regard to severity of comorbidities. Additionally, while we accounted for patient physical status by adjusting for ASA class in our regression model, the ASA variable in the database may have issues with misclassification (Curatolo et al. 2017; Nafiu et al. 2021). Indeed, our study included a proportion of patients with ASA classifications not concordant with elective bariatric surgery (e.g., ASA class V). Nevertheless, the multitude of baseline clinical and sociodemographic variables available in the MBSAQIP allowed us to extensively describe the characteristics of our study cohort.

Conclusions

Irrespective of baseline diabetes status, knowledge of A1C values before MBS can influence perioperative care. Until recent years, however, less than half of patients undergoing MBS had their A1C measured preoperatively and those with baseline diabetes were more likely to be tested. Notably, there has been a steady increase overtime in the proportion of patients tested. Further studies are needed to identify potential barriers to testing and to understand the full benefit achieved with universal preoperative testing.

Abbreviations

A1C	Hemoglobin A1c
MBS	Metabolic and bariatric surgery
ASMBS	American society of metabolic and bariatric surgery
MBSAQIP	Metabolic and bariatric surgery accreditation and quality improvement program
RYGB	Roux-en-Y gastric bypass
MBSCR	Metabolic and bariatric surgical clinical reviewer
STROBE	The strengthening the reporting of observational studies in epidemiology
CPT	Current procedural terminology
BMI	Body mass index
ASA	American society of anesthesiologists
COPD	Chronic obstructive pulmonary disease
PE	Pulmonary embolism
GERD	Gastroesophageal reflux disease
MI	Myocardial infarction
PCI/PTCA	Primary coronary intervention/percutaneous transluminal coronary angioplasty
HTN	Hypertension
HLD	Hyperlipidemia
DVT	Deep vein thrombosis
IVC	Inferior vena cava
SD	Standard deviation
IQR	Interquartile range
aOR	Adjusted odds ratio

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Authors' contributions

S.A.H, E.G, E.S, and K.E.G conceptualized the study. S.A.H, E.G, E.S, and K.E.G performed data analysis. S.A.H, E.G, E.J.Z, K.S, E.S, and K.E.G interpreted the data. S.A.H wrote original manuscript. S.A.H, E.G, E.J.Z, K.S, E.S, and K.E.G edited the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets analyzed during the current study are available in the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) repository: https://www.facs.org/quality-programs/accreditation-and-verification/metabolic-and-bariatric-surgery-accreditation-and-quality-improvement-program/participant-use-data-file-puf/

Declarations

Ethics approval and consent to participate
The Yale Human Investigation Committee determined that this study did not constitute human participants research and did not require institutional review board approval. Consent to participate is not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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