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ORIGINAL RESEARCH

Cost-Utility Analysis of Metabolic Bariatric Surgery for Individuals with Obesity in Saudi Arabia

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Background: Metabolic bariatric surgery (MBS) is an effective and relatively safe intervention for managing obesity. This study aimed to evaluate the cost-utility of MBS compared with the standard treatment—lifestyle modification plus liraglutide—in the Kingdom of Saudi Arabia (KSA).

Methods: A Markov model was developed to estimate the lifetime costs and outcomes of MBS. Costs and outcomes were discounted at an annual rate of 3%. The analysis was conducted from societal and healthcare system perspectives, using a willingness-to-pay (WTP) threshold of one to three times the gross domestic product (GDP) per capita per quality-adjusted life years (QALY) gained. Direct medical and nonmedical costs were obtained from hospital records and patient surveys, respectively. Transitional probabilities and utility values were obtained from published literature and primary data collection in the KSA. One-way and probabilistic sensitivity analyses were performed to assess parameter uncertainty.

Results: Over a lifetime horizon, MBS yielded 0.38 incremental QALY and US$ 11,975 (Saudi Riyal [SAR] 44,905; purchasing power parity [PPP] 23,911) incremental costs, leading to an incremental cost-effectiveness ratio (ICER) of US$ 31,909 (SAR 119,660; PPP 63,717) per QALY gained from a societal perspective and US$ 36,353 (SAR 136,324); PPP 72,590) from a healthcare system perspective. The model was most sensitive to the discount rates of costs and outcomes and the direct medical costs associated with MBS. At a WTP threshold of one GDP per capita (US$ 30,436; SAR 114,135; PPP 60,775), the standard treatment had a 63% probability of being cost-effective. However, at a threshold of approximately 1.8 GDP per capita (US$ 56,000; SAR 210,000; PPP 111,821), MBS was cost-effective in 100% of the iterations.

Conclusion: MBS is a cost-effective intervention compared with standard treatment in the context of the KSA. Efforts should be made to expand earlier and equitable access to MBS for individuals with a BMI > 40 kg/m^2 without comorbidities across the country.

Keywords: economic evaluation, cost-utility, obesity, Saudi Arabia, metabolic bariatric surgery

Introduction

Obesity is a major public health concern globally and in the Kingdom of Saudi Arabia (KSA).[1] Weight loss among individuals with obesity is strongly associated with significant health (comorbidity improvement, disease remission, and quality of life gains)[2] and economic (healthcare costs reduction and productivity improvement)[3] benefits. The current clinical management of obesity involves lifestyle modification and pharmacotherapy. However, Metabolic bariatric surgery (MBS) is recommended if these interventions fail to attain adequate weight loss or desired clinical outcomes.[4]

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MBS includes a range of gastrointestinal procedures intended to induce sustained weight loss and improve long-term health outcomes. Among these procedures, sleeve gastrectomy (SG) is the most commonly performed. It involves removing a large portion of the stomach to reduce appetite and restrict food intake.[2,5] SG accounts for 58% of global bariatric surgeries[6] and nearly 100% in the KSA.[7] It has been shown to deliver durable weight loss and substantial improvement in obesity-related comorbidities, with low complication rates.[2]

Saudi clinical guidelines currently recommend MBS for adults with a body mass index (BMI) ≥ 40 kg/m², irrespective of the presence of baseline comorbidities, or a BMI ≥ 35 kg/m² with at least one obesity-related comorbidity.[8] In contrast, international guidelines updated in 2022 recommend MBS for individuals with a BMI >35 kg/m², regardless of the presence, absence, or severity of comorbidities, or a BMI of 30–34.9 kg/m² with at least one obesity-related comorbidity. This evolution reflects the importance of enabling earlier access to MBS to optimize patient outcomes.[9] Recent evidence further demonstrates that expanding eligibility to individuals without baseline comorbidities can yield significant and meaningful clinical and economic outcomes. These advantages extend beyond weight loss and BMI reduction, especially in countries heavily affected by the obesity epidemic.[10]

The KSA faces a rapidly rising in obesity epidemic.[11] As of current estimates, 40.6% of adults (37.3% of males and 46.6% of females) live with obesity (BMI ≥30 kg/m²), while only about 31% maintain a healthy weight (BMI < 25 kg/m²).[12] This escalating burden has been linked to an increased incidence of noncommunicable diseases, elevated healthcare expenditures, reduced productivity, and lower quality of life.[13] In 2022, obesity-related healthcare and societal costs in the KSA were estimated at US$ 110.6 and US$ 117 billion, respectively.[13]

Despite the heavy burden of obesity and the well-documented evidence supporting the clinical and economic benefits of MBS, access remains limited due to systemic and structural barriers.[11,14] While universal health coverage in the KSA offers full access to eligible citizens,[15] public hospitals, in practice, often prioritize individuals with obesity-related comorbidities. As a result, individuals without baseline comorbidities face lengthy waiting times, sometimes stretching over several years. Over time, these delays increase the risk of progression to costly complications, thereby worsening the burden on the healthcare system and society. Simultaneously, private insurance schemes in the KSA are highly restrictive, covering SG only for individuals with a BMI ≥ 45 kg/m²—contrary to clinical guidelines recommending surgery for those with a BMI ≥ 40 kg/m² without comorbidities.[8] Consequently, individuals with a BMI between 40 and 45 kg/m² often face financial hardship due to out-of-pocket costs or miss timely care, resulting in inequitable access and poorer outcomes.[10,14,16]

With over 1.9 million individuals in the KSA having a BMI ≥ 40 kg/m², with numbers rising annually, there is an urgent need to evaluate the value (costs and outcomes) of MBS among this under-served yet significant segment of this growing population.[17] This can be effectively addressed through cost-utility analysis (CUA), a form of health economic evaluation that compares the cost of interventions to the benefits they produce, typically measured in quality-adjusted life years (QALY), guides informed policy and resource allocation decisions.[18]

In this context, MBS has been consistently demonstrated to be cost-effective and, in some cases, cost-saving across high-income settings with a high obesity prevalence.[3] However, despite a growing body of international evidence,[3] there remains a lack of evidence specific to the KSA and the wider Gulf Cooperation Council (GCC) region. This gap in the literature may limit the ability of policymakers to make informed decisions.

Therefore, this study aimed to evaluate the cost-utility of MBS compared with standard treatment (ie, lifestyle modification plus liraglutide 3 mg daily) among adults with a BMI > 40 kg/m² without obesity-related comorbidities in the KSA. The analysis adopted both societal and healthcare system perspectives. The findings are intended to inform evidence-based policy development and support strategic planning to expand access to MBS. They also aim to help refine the insurance coverage criteria. Ultimately, this CUA seeks to contribute to guiding national efforts to control the growing obesity epidemic in the KSA more equitably and efficiently.

Methods

Target Population

The target population of this study comprised adult individuals aged 18 years and older with a BMI > 40 kg/m² without any comorbidities in the KSA.

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Intervention and Comparator

This study evaluated laparoscopic sleeve gastrectomy (LSG), the most common bariatric-metabolic surgical procedure performed in the KSA, compared with standard treatment (ie, lifestyle modification plus liraglutide 3 mg daily), which is the most commonly used anti-obesity pharmacotherapy in the KSA. The effectiveness data of both the intervention and the comparator have been extensively documented in the literature. MBS has long-term effects on weight loss and improvements in obesity-related comorbidities among the majority of patients with obesity.[2,19] Similarly, adjunct pharmacotherapy leads to meaningful clinical outcomes.[4] For instance, liraglutide induces weight loss in patients living with obesity, as shown in clinical trials.[20]

Model Structure

A Markov model was developed using Microsoft Excel 2019 (Microsoft Corp., Redmond, WA) to estimate the costs and health outcomes (ie, QALYs) of MBS versus standard treatment from both societal and healthcare system perspectives over a lifetime horizon, in accordance with CUA practices.[21] The Markov model was developed based on the natural history of obesity. There were seven mutually exclusive health states, including obesity; improved BMI; four obesity-related disease states [ie, T2DM, stroke, coronary heart disease (CHD), and cancer]; and a death state, as displayed in Figure 1. This model was validated with local obesity experts and surgeons to ensure the reliability and sensibility of the model structure, assumptions, and parameters. According to the model, each subject entered the model through the obesity health state. Then, the subject could either transition to an improved BMI health state (ie, BMI < 30 kg/m²) or remain in the obesity health state. Individuals in both the obesity health state and the improved BMI health state were at risk of developing obesity-associated diseases (ie, stroke and CHD, T2DM, and cancer) or death. At the end of each cycle, individuals could either remain in the same health state (represented by the circular arrow in the model) or progress through another health state. The cycle length in this model was one year.

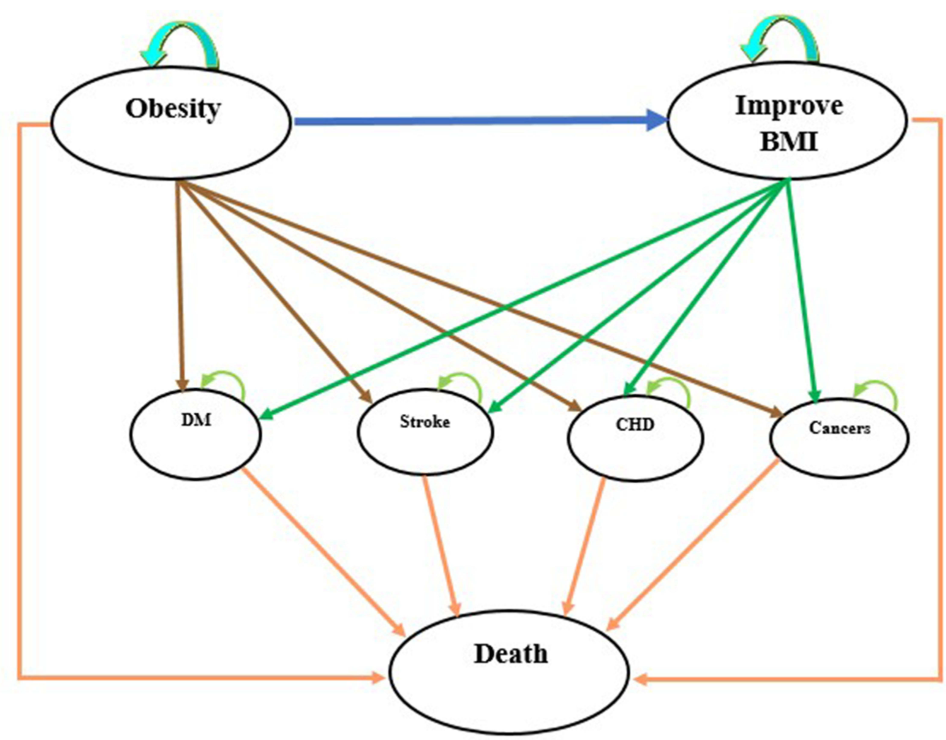

Figure 1 Markov model structure.
Abbreviations: BMI, Body mass index; CHD, Coronary heart disease; DM, diabetes mellitus.

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Model Assumptions

It was assumed that the costs of treating obesity-related comorbidities (ie, T2DM, stroke, CHD, and cancer) were similar in both the surgical and nonsurgical groups. Additionally, each patient in the surgical group was assumed to undergo surgery only once in their lifetime. For the surgery group, it was further assumed that no anti-obesity pharmacotherapies would be used during the first 10 years following surgery, as current evidence suggests that the weight-loss effects of MBS persist for at least a decade.[2] Moreover, individuals who transitioned to the improved BMI health state (ie, BMI < 30 kg/m²) after MBS were assumed not to return to the obesity state; however, they would begin liraglutide therapy 10 years after surgery to help maintain their BMI. In line with previous cost-effectiveness modeling studies,[22,23] all obesity-related cancers (listed in Supplementary Table S1) were aggregated into a single health state. Finally, the model assumed consistent adherence to lifestyle modifications and pharmacotherapy in the standard care arm, as well as compliance with post-surgical dietary and follow-up recommendations in the surgical arm.

Discount Rate and Threshold

Costs and utilities (QALY) beyond the first year were discounted by 3% as per the World Health Organization (WHO) recommendations.[24] Similarly, given the absence of an official cost-effectiveness threshold for healthcare interventions in the KSA, the willingness-to-pay (WTP) threshold in this CUA was set at one gross domestic product (GDP) per capita (US$ 30,436 or Saudi Riyal 114,135; purchasing power parity [PPP] 60,775) to three GDP per capita (US$ 91,308 or SAR 342,405; PPP 182,324) per QALY in 2022,[25] based on the WHO recommendation for developing countries.[21,24]

Model Parameters

Transitional Probabilities

The transitional probabilities used in this analysis were estimated on the basis of data from published studies,[26–36] primary data collected in the KSA, and assumptions, as shown in Table 1. In short, the annual transition probability from the obesity state to the improved BMI state (ie, BMI < 30 kg/m²) for the surgery group was set at 0.035. This value was validated and supported by findings from a large registry database,[37] indicating that the model did not underestimate the effectiveness of MBS. This relatively low transition probability reflects that not all patients, especially those with a baseline BMI > 40 kg/m², achieve BMI < 30 kg/m². Nonetheless, even if the BMI target < 30 kg/m² is not reached, MBS confers substantial benefits in weight reduction, disease remission, comorbidity improvement, and quality of life compared with standard treatment.[37–39] Conversely, standard treatment (ie, lifestyle modification plus liraglutide 3 mg

Table 1 Input Parameters

Parameter	Mean	SE	Source
Annual transitional probabilities			
Obesity to CHD	0.008	0.00023	[35]
Improved BMI to CHD	0.006	0.00006	[35]
Obesity to T2DM	0.050	0.00048	[34]
Improved BMI to T2DM	0.035	0.00024	[34]
Obesity to stroke	0.002	0.00184	[31]
Improved BMI to stroke	0.0003	0.000002	[26]
Obesity to cancer	0.0099	0.000001	[33]
Improved BMI to cancer	0.0097	0.000001	[33]
Obesity to improved BMI in bariatric surgery group	0.035	0.00001	[29]

(*Continued*)

Table 1 (Continued).

Parameter	Mean	SE	Source
Obesity to improved BMI in standard treatment group	0.000	–	Primary data collection
Improved BMI to obesity in bariatric surgery group	0.000	–	Assumption
Obesity to death	0.032	0.00001	[27]
Improved BMI to death	0.014	0.00001	[27]
CHD to death	0.112	0.00005	[30]
T2DM to death	0.027	0.00131	[28]
Stroke to death	0.012	0.00237	[36]
Cancer to death	0.038	0.00131	[32]
Cost inputs			
Direct medical cost (SAR)			
Annual cost of standard treatment	19,071	1,907	Hospital database
Cost of surgery, first year	31,575	3,158	Hospital database
Cost of surgery, 2nd to 10th year	130	13	Hospital database
Cost of weight-lowering agents in the surgery group, beyond 10th year	7,218	722	Hospital database
Annual cost of CHD treatment	643,822	64,382	Hospital database
Annual cost of stroke treatment	76,528	7,653	Hospital database
Annual cost of T2DM treatment	62,000	6,200	Hospital database
Annual cost of cancer treatment	562,819	56,282	Hospital database
Direct non-medical cost (SAR)			
Annual cost of transportation (standard treatment)	5,447	545	Patients' survey
Annual cost of transportation (surgery group)	2,355	236	Patients' survey
Annual cost of food (standard treatment)	1,339	134	Patients' survey
Annual cost of food (surgery group)	968	97	Patients' survey
Annual cost of accommodation (standard treatment)	3,534	353	Patients' survey
Annual cost of accommodation (surgery group)	3,733	373	Patients' survey
Annual cost of home renovation (standard treatment)	298	30	Patients' survey
Annual cost of home renovation (surgery group)	32	3	Patients' survey
Annual cost of home equipment (standard treatment)	119	12	Patients' survey
Annual cost of home equipment (surgery group)	264	26	Patients' survey
Annual cost of other requirements (standard treatment)	26	3	Patients' survey
Annual cost of other requirements (surgery group)	0	0	Patients' survey
Annual cost of caregiver productivity loss (standard treatment)	2,350	235	Patients' survey
Annual cost of caregiver productivity loss (surgery group)	1,674	167	Patients' survey

(*Continued*)

Table 1 (Continued).

Parameter	Mean	SE	Source
Utility values			
Obesity	0.750	0.750	[40,41]
Improved BMI	0.870	0.870	[40,41]
Obesity with T2DM	0.700	0.700	[42]
Obesity with CHD	0.643	0.643	[43]
Obesity with Stroke	0.600	0.600	[44]
Obesity with Cancer	0.688	0.688	[45]
Improved BMI with T2DM	0.847	0.847	[42]
Improved BMI with CHD	0.696	0.696	[43]
Improved BMI with Stroke	0.763	0.763	[44]
Improved BMI with Cancer	0.808	0.808	[45]

Abbreviations: BMI, Body Mass Index; CHD, Coronary Heart Diseases; SAR, Saudi Riyal; SE, Standard Error; T2DM, Type two Diabetes Mellitus.

daily) can improve BMI but cannot transition patients from the obesity health state to the improved BMI health state (ie, BMI < 30 kg/m²), as shown by the primary data collected from King Fahad Medical City (KFMC). Thus, this transitional probability was set to zero, reflecting the extremely low likelihood of reaching a BMI < 30 kg/m² among individuals with a BMI > 40 kg/m² without surgery.

In the meantime, owing to data limitations, the transitional probability from the cancer health state to the death health state was modeled using the transitional probability of colorectal cancer to death[32] as a proxy for all cancer types, since colorectal cancer is one of the most common cancers in the KSA, accounting for 14.6% of all cancer cases.[46] Similarly, the transition probability from the stroke health state to death was modeled using the probability of death from ischemic stroke[31] as a proxy for overall stroke-related mortality. In the KSA, ischemic stroke accounts for the majority of stroke cases, with studies reporting a range of 79–87%.[47] Furthermore, age-dependent baseline mortality rates were incorporated with the death risk from other disease complications using national life tables to better reflect the increasing mortality risk associated with age.[48] Additionally, age-dependent baseline mortality rates were incorporated using national life tables to more accurately reflect the increasing mortality risk with age.[48]

Cost Parameters

All costs were reported in 2022 values in SAR and then converted to US$ and PPP based on the 2022 official exchange rates. One US$ equals 3.75 SAR, whereas one PPP equals 1.878 SAR.[49,50]

Direct Medical Costs

The direct medical costs of MBS comprehensively included the average costs of initial surgery (ie, outpatient visits, diagnostic tools, laboratory tests, operation room requirements, inpatient days, postoperative follow-up visits), management of surgical complications (ie, leakage, infection, or bleeding), and any necessary revisional procedures, reflecting real-world resource use inclusive of both uncomplicated and complicated cases. The costs of surgeries and surgical complications were rolled into the cost of surgery in the first year of surgery. Likewise, the direct medical cost of standard treatment included the costs of visiting healthcare facilities, laboratory tests, diagnostic tools, liraglutide, and managing medication adverse events. All cost data were derived from detailed medical records of adult patients (18 years old and older)–identified via International Classification of Disease (ICD-10) codes– who received obesity care (either MBS or standard treatment) at KFMC hospitals, Riyadh, KSA, from January to July 2022, as shown in Table 1. The direct medical costs were not stratified by age or sex; thus, they were modeled for the combined population of both sexes. The KFMC is one of the largest governmental medical facilities in the KSA with a total capacity of 1,200 beds, generating 30,000 inpatient days and 500,000 outpatient visits annually.

Direct Nonmedical Costs

Data on nonmedical costs such as meals, transportation, accommodation and any other requirements of patients or relatives/caregivers during their hospital visit/stay, as well as treatment-related time costs (ie, time lost by relatives/caregivers while seeking medical care), were obtained through face-to-face interviews with 116 adult participants receiving obesity care (either MBS or standard treatment) over six months (January to June 2022). In accordance with standard CUA practices as outlined by Drummond et al, QALYs capture health-related quality-of-life impacts, including patient productivity losses.[40] Consequently, the inclusion of patient productivity costs would constitute double counting and was therefore excluded from this study. The average age of the participants was 40.4 years, with an average BMI of 44.86 kg/m², and 72% were female. These baseline characteristics of the participants reflect the typical demographic profile of adults with a BMI > 40 kg/m² undergoing bariatric care in the KSA, consistent with published epidemiological data,[41] which reported a mean age around 35–40 years, a predominance of middle-aged adults, and a higher proportion of females within this population. Trained graduated medical/pharmacy personnel or nurses at the KFMC conducted the interviews through a structured questionnaire developed by the research team. Participants were included in the interviews if they were ≥ 18 years old, had a BMI > 40 kg/m^2, and received obesity care at the KFMC. Individuals with disabilities, cognitive impairment, or terminal conditions and pregnant women were excluded from the interviews.

Utility Parameters

The utility values associated with each model health state were derived from the published literature,[42–45,51,52] as shown in Table 1. To estimate the utility of people living with obesity and complications, the disutility method was adopted. For example, the utility decreased from stroke in the general population was subtracted from the utility of people living with obesity to estimate the utility of stroke in people living with obesity (ie, utility of stroke among people living with obesity = utility of people living with obesity - disutility of stroke in the general population).

Result Presentation

The findings of this study were total costs, life years, quality-adjusted life years (QALY), and the incremental cost-effectiveness ratio (ICER). The ICER was calculated in SAR, US dollars, and PPP. An ICER lower than one GDP per capita is considered very cost-effective, an ICER of one GDP per capita to less than three GDP per capita is considered cost-effective, and an ICER higher than three GDP per capita is not cost-effective.[21,24]

Uncertainty Analysis

One-way deterministic sensitivity analysis was conducted to evaluate the robustness of the base-case results and the effect of changing one model parameter while keeping other variables constant at base-case values. The results of this analysis are shown in a tornado diagram. Furthermore, a probabilistic sensitivity analysis (PSA) was also performed to address the model uncertainty by randomly changing all major parameters simultaneously within reasonable ranges using 1000 Monte Carlo simulations to show the acceptability curve and cost-effectiveness plane. The gamma distribution was used for the cost values (positive values), and the beta distribution was used for the transition probabilities and utility values (ranging from 0 to 1).

Ethical Approval

This study was approved by the institutional review board (IRB) committee of the faculty of medicine at the KFMC, Riyadh-KSA, under number H-01-R-012 (IRB log number: 21–403) on October 31, 2021. Patient information sheets and informed consent forms (both in Arabic) were provided to, signed by, and collected from all participants before the interviews.

Table 2 Total Life year, QALY and ICER of Each Strategy in Base-Case Analysis

Intervention	Total Cost (SAR)	Total Effectiveness		Incremental Cost (SAR)	Incremental Effectiveness		ICER (SAR/ QALY)
		LY	QALY		LY	QALY	
Healthcare system perspective							
Standard treatment	449,986	6.316	4.593				
Surgery	501,145	6.720	4.968	51,159	0.40	0.38	**136,324**
Societal perspective							
Standard treatment	512,016	6.316	4.593				
Surgery	556,992	6.720	4.968	44,905	0.40	0.38	**119,660**

Abbreviations: ICER, Incremental cost-effectiveness ratio; LY, Life year; QALY, Quality-adjusted Life year; SAR, Saudi Riyal.

Results

Base-Case Analysis

The results of the base-case analysis are summarized in Table 2. From a societal perspective, MBS costs US$ 148,512 (SAR 556,922; PPP 296,550) and yields 6.720 LY and 4.968 QALY, whereas the standard treatment costs US$ 136,538 (SAR 512,016; PPP 272,639) and yields 6.316 LY and 4.593 QALY, giving an ICER of US$ 29,668 (SAR 111,256; PPP 59,242) per LY saved and US$ 31,909 (SAR 119,660; PPP 63,717) per QALY gained. Considering a healthcare system perspective, the ICER was US$ 33,800 (SAR 126,749; PPP 67,492) per LY saved and US$ 36,353 (SAR 136,324; PPP 72,590) per QALY gained (Figure 2).

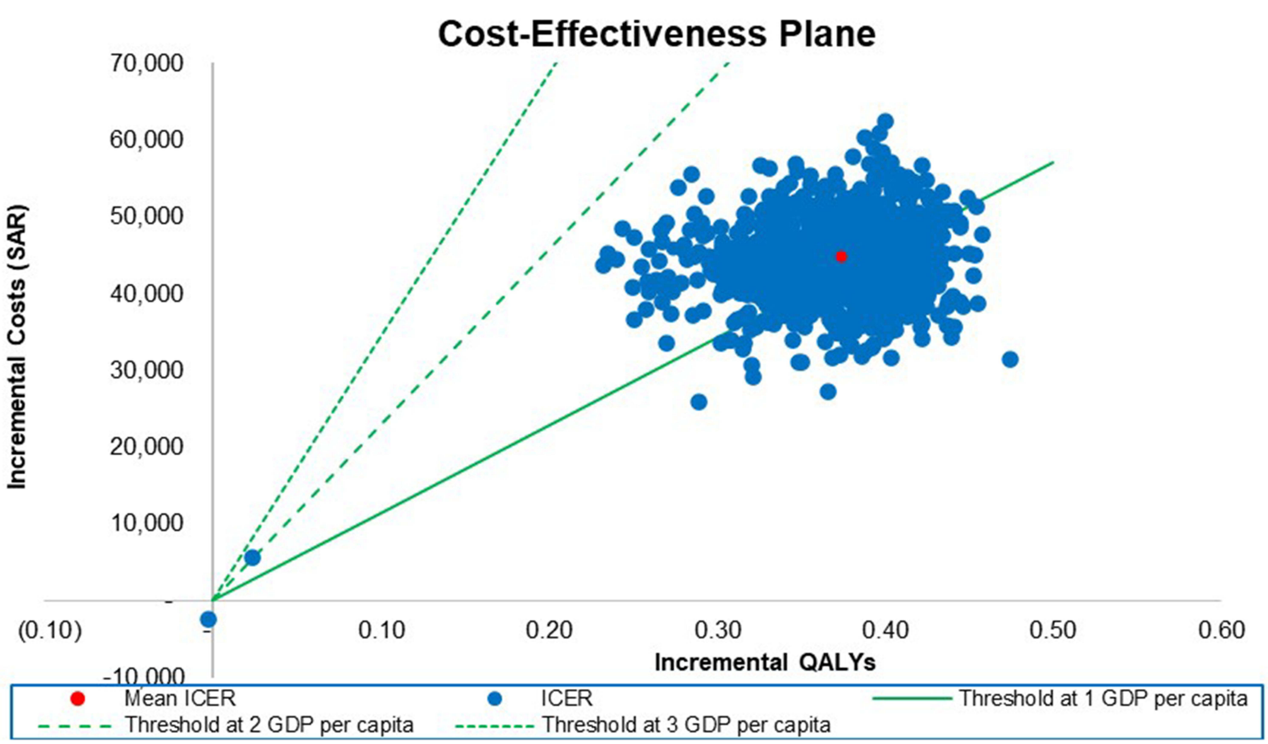

Figure 2 Cost-effectiveness plane.

Abbreviations: GDP, Gross Domestic Product; ICER, Incremental cost-effectiveness ratio; QALY, Quality-adjusted Life year; SAR, Saudi Riyal.

Uncertainty Analysis Results

One-Way Sensitivity Analysis

Based on the one-way sensitivity analysis, the five most significant parameters that affected the ICER value were the discounting rate for costs, discounting rate for outcomes, direct medical costs associated with MBS, direct medical cost of cancer, and direct medical costs associated with standard treatment, as presented in the Tornado diagram (Figure 3).

Cost–effectiveness Acceptability Curve (CEAC)

From a societal perspective, at the WTP threshold of one GDP per capita per QALY, US$ 30,436 (SAR 114,135; PPP 60,775), the standard treatment had a 63% probability of being cost-effective and MBS had a 37%. Meanwhile, at the WTP threshold of approximately 1.8 GDP per capita per QALY, US$ 56,000 (SAR 210,000; PPP 111,821), MBS was more cost-effective than the standard treatment in 100% of the iterations (Figure 4).

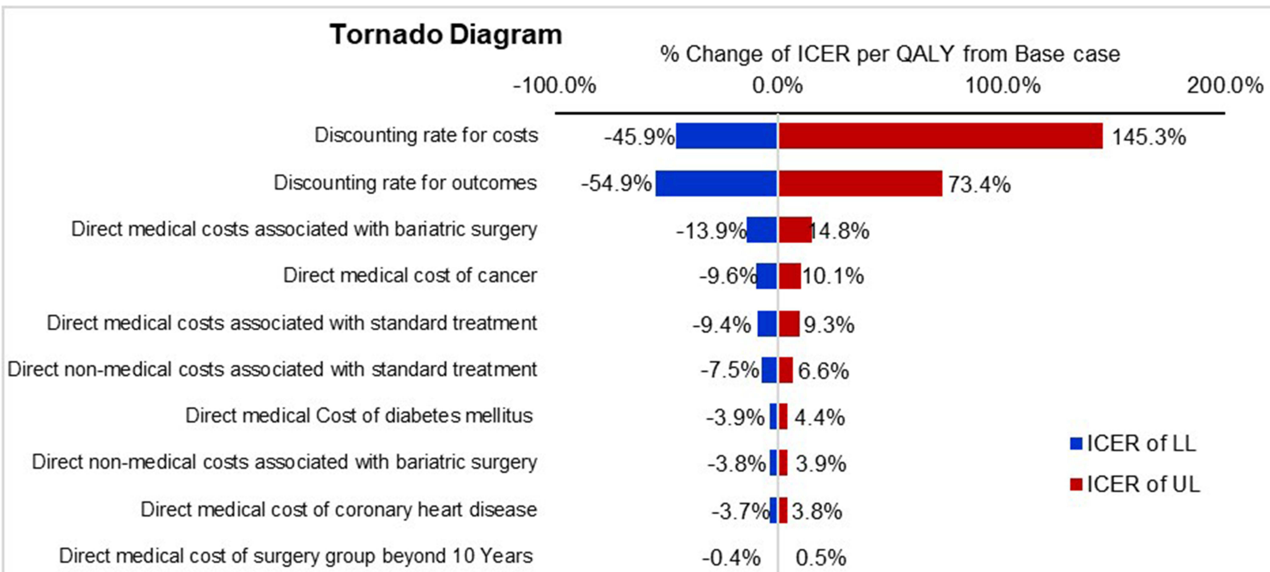

Figure 3 Tornado diagram of one-way sensitivity analysis.

Abbreviations: ICER, Incremental cost-effectiveness ratio; LL, Lower limit; QALY, Quality-adjusted life year; UL, Upper limit.

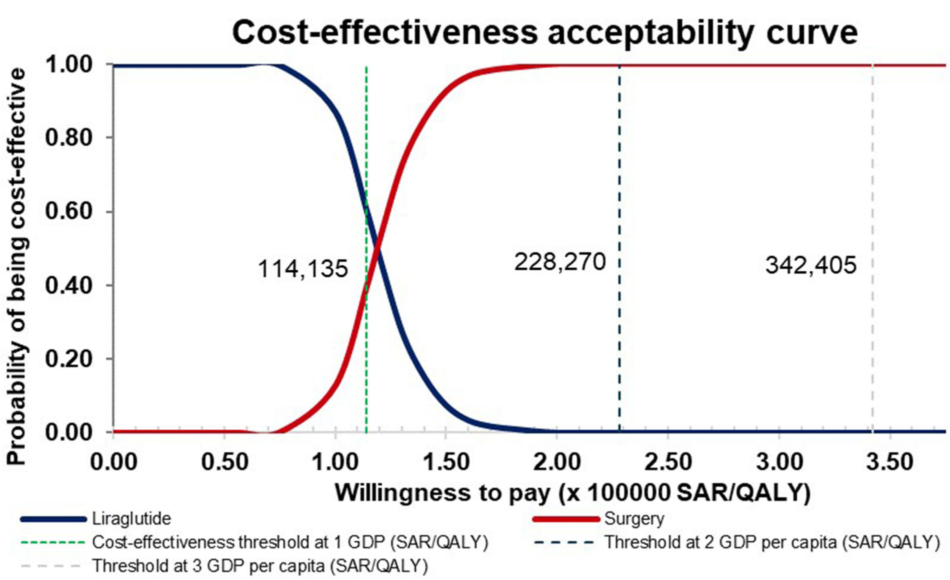

Figure 4 Cost-effectiveness acceptability curve.

Abbreviations: GDP, Gross Domestic Product; QALY, Quality-adjusted Life year; SAR, Saudi Riyal.

Discussion

This study revealed that MBS is a cost-effective strategy in the KSA, considering a WTP threshold of three GDP per capita per QALY, US$ 91,308 (SAR 342,405; PPP 182,324) from both healthcare system and societal perspectives. These findings are in line with several previous studies conducted in other countries, which reported that MBS is a cost-effective or even cost-saving intervention among patients with severe obesity (BMI ≥ 40 kg/m²).[53,54] However, it is important to note that many of these earlier studies analyzed the cost-effectiveness of MBS among a specific population or among patients with individual comorbidities, concluding that MBS was a cost-effective strategy among people living with obesity and different comorbidities.[3,55]

In contrary, this CUA is the first to show that MBS is a cost-effective intervention in the KSA among people with a BMI > 40 kg/m^2 without comorbidities. As such, these findings do not extend to individuals with existing obesity-related diseases at baseline. Moreover, the imminent availability of emerging pharmacotherapies, such as semaglutide, tirzepatide, and novel combination agents, may substantially alter the management of obesity. As this analysis reflects current standards of care, future access to more effective or less costly treatments could reshape the cost-effectiveness landscape and, consequently, impact cost-utility conclusions.[56]

In terms of the cost-effectiveness threshold, the KSA has not yet set an explicit threshold for healthcare interventions and technologies to inform the maximum cost per unit of health outcome that a health system is capable of paying. As such, this CUA adopted the commonly used threshold of one- to three-times GDP per capita per QALY, as proposed by the WHO guidelines.[21,24] This threshold has been repeatedly criticized for lacking empirical justification and has been subject to debate, particularly in high-income countries such as the KSA, where it may be viewed as overly permissive—potentially classifying many interventions as cost-effective.[57] Hence, future research is warranted to establish a context-specific cost-effectiveness threshold incorporating Saudi healthcare system characteristics, societal preferences, national priorities, and fiscal capacity.[58] Indeed, previous economic evaluation studies including CUA in the KSA adopted various WTP thresholds, such as one- to three-times GDP per capita per QALY,[59] US$ 20,283 per QALY,[60] US$ 50,000 per QALY,[61] and US$ 100,000 par QALY.[62] Nevertheless, many researchers have recently proposed a cost-effectiveness threshold for the KSA. For example, one study suggested a threshold of US$ 13,333 to 20,000 per QALY, equivalent to 58% to 86% of GDP per capita.[63] Hence, given all these suggested thresholds, the findings of this CUA demonstrated that MBS remains highly cost-effective at thresholds below two GDP per capita per QALY and approaches cost-effectiveness at one GDP per capita, indicating robustness across a range of plausible thresholds. Nonetheless, decision-makers should interpret these findings in light of evolving local thresholds, healthcare priorities, and resource availability.

This CUA faced several limitations primarily due to data scarcity in the KSA, which necessitated the use of diverse sources for key model inputs such as transitional probabilities and utility values. Although the uncertainties surrounding the model parameters were examined via deterministic and probabilistic analyses, some degree of uncertainty remains, particularly structural uncertainty stemming from limited local data. Consequently, the findings of this study should be interpreted with some caution.

First, the cost input data were derived from a single tertiary hospital in the KSA—where unit costs are likely higher than the national average—limiting the generalizability and representativeness of our findings for the broader Saudi healthcare system. Future analyses should incorporate multicenter cost data from diverse public and private facilities across different regions to enhance the external validity.[40,64] As such, the findings are context-specific to the KSA and reflect the local healthcare system and treatment patterns. Accordingly, the ICERs and conclusions presented in this CUA may not be directly applicable to other settings without appropriate adjustments for local cost structures, clinical guidelines, and population characteristics. Second, another key limitation is that the utility data and transitional probabilities were obtained from published literature from countries with different characteristics, norms, and healthcare provision mechanisms. Of note, in our model, the transitional probability from the cancer health state to the death health state was modeled using the transitional probability of colorectal cancer to death[32] as a proxy for others, since colorectal cancer is one of the most common cancers in the KSA, accounting for 14.6% of all cancer cases.[46] However, this approach is likely to underestimate the mortality of more aggressive obesity-related cancers, such as esophageal, pancreatic, gallbladder, liver, and stomach cancers.[65] Similarly, the transitional probability from the stroke health state to the death was modeled using the transitional probability of ischemic stroke to death[31] as a proxy for overall stroke-related mortality. In the KSA, ischemic stroke accounts for the majority of stroke cases, comprising 79–87% of all cases.[47] These simplifications, necessitated by data limitations, may not accurately represent the true mortality associated with these health states but are consistent with previous cost-effectiveness modeling studies.[22,23] Hence, we emphasize the critical need for future research to generate Saudi-specific utility weights and long-term outcome data. Such efforts will enhance model accuracy and strengthen the evidence base for policy decisions regarding obesity management in the country. Third, our model assumes sustained weight loss following surgery, without reverting to the obesity health state, given the limited long-term data on weight regain. While modeling the costs of liraglutide 10 years post-surgery partially addresses this concern, the model does not capture the potential declines in health outcomes and quality of life associated with recurrent weight gain. Such an approach may overestimate the benefits; however, it reflects the currently available evidence, which indicates sustained weight loss following surgery, a minimal rate (1.3%) of weight regains,[66,67] and the effectiveness of liraglutide in maintaining weight loss after MBS.[68] At the same time, it preserves model simplicity, ensuring relevance for policy decision-making. Fourth, given the relatively low incidence of serious surgical complications and perioperative mortality, the health impact of surgical complications—such as quality of life decrements during recovery or the small risk of perioperative mortality—was not modeled either as separate health state/s or immediate outcome node/s prior to entering the Markov model. Existing evidence indicates that MBS is generally safe, and the long-term benefits substantially outweigh these minimal upfront risks for most patients.[2] Therefore, the authors anticipate that omitting these early surgical risks will have a negligible impact on the overall cost-utility results. Nonetheless, we acknowledge this as a methodological limitation and recommend that future research incorporate an explicit modeling of immediate surgical outcomes to better capture early risks, thereby strengthening the robustness and comprehensiveness of the analysis. Fifth, this CUA lacks explicit age- and sex-specific modeling, which may limit the accuracy of the estimates. Differences in obesity prevalence, comorbidity risk, and treatment outcomes by sex and age are well documented and could influence the results. Future research incorporating detailed, population-specific data would enable more nuanced modeling and improve the robustness of economic evaluations in this context. Sixth, another limitation of our model is the assumption of continuous adherence to lifestyle modifications and pharmacotherapy in the standard care arm, as well as adherence to post-surgical dietary and follow-up recommendations in the surgery arm. In reality, long-term adherence is often suboptimal due to factors including side effects, cost, and patient motivation, which can significantly impact their effectiveness and reduce expected benefits.[69] These factors are challenging to model due to the limited data. As such, this assumption may overestimate the effectiveness of standard care, potentially yielding a conservative estimate of the true cost-effectiveness of MBS.

Conclusion

Considering the current threshold of three times GDP per capita, US$ 91,308 (SAR 342,405; PPP 182,324), MBS is a cost-effective intervention among individuals with obesity (BMI > 40 kg/m^2) without any comorbidities from the healthcare system and societal perspectives, in the context of the KSA. In this sense, to promote earlier and more equitable access to MBS and protect patients from catastrophic healthcare expenditures, it is recommended to integrate the MBS into standard care across all qualified public and private healthcare facilities. Strategic investments should prioritize expanding the national surgical capacity by increasing the number of trained specialists, upgrading the infrastructure, and streamlining the referral systems to reduce wait times and meet the rising demand. In parallel, aligning private insurance coverage with national clinical guidelines and incentivizing private sector participation can alleviate the pressure on public facilities. To guide sustainable policy decisions, it is crucial to establish a cost-effectiveness threshold that reflects the structure of the local healthcare system, national priorities, and societal values. Additionally, evaluating the cost-effectiveness of MBS in patients with different comorbidities can help prioritize interventions and optimize resource allocation. Finally, the development of national registries to track surgical outcomes, wait times, and costs will enable continuous policy refinement and improve the overall healthcare system performance.

Abbreviations

BMI, Body mass index; CHD, Coronary heart disease; CUA, Cost-utility analyses; GCC, Gulf Cooperation Council; GDP, Gross domestic product; ICD, International classification of disease; ICER, Incremental cost-effectiveness ratio;

IRB, Institutional review board; KFMC, King Fahad Medical City; KSA, Kingdom of Saudi Arabia; LSC, Laparoscopic sleeve gastrectomy; MBS, Metabolic bariatric surgery; PPP, Purchasing power parity; PSA, Probabilistic sensitivity analysis; QALY, Quality-adjusted life years; SAR, Saudi Riyal; SG, Sleeve gastrectomy; T2DM, Type II diabetes mellitus; WHO, World Health Organization.

Data Sharing Statement

Most of the data generated and/or analyzed during the study are included in this article. The complete datasets are available from the corresponding author(s) upon reasonable request.

Consent to Participate

The current study complies with the Declaration of Helsinki. The participant information sheet and informed consent form were provided to and signed by all individual participants before the interview.

AI Tools Utilization

During the preparation of this work, the author(s) used Perplexity and ChatGPT AI tools to assist with language editing, grammar correction, and to improve overall readability, in accordance with ethical standards.

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Author Contributions

All authors contributed substantially to the work, including its conception, study design, execution, data acquisition, analysis, and interpretation. They were also involved in revising or critically reviewing the manuscript, approved the final version for publication, agreed on the target journal, and took full responsibility for all aspects of the work. MAN was specifically responsible for drafting the manuscript.

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Disclosure

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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