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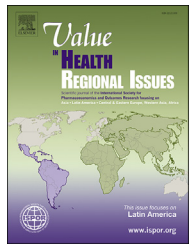

Economic Evaluation

Cost-Effectiveness of Bariatric Surgery Compared With Nonsurgical Treatment in People With Obesity and Comorbidity in Colombia

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ABSTRACT

Background: The increase in obesity prevalence and its relationship with multiple cardiovascular complications have raised the burden of obesity in the general population. Bariatric surgery has shown to be more effective in reducing weight than the traditional pharmacologic and nonpharmacologic treatments. **Objective:** To evaluate the cost-effectiveness of this alternative compared with standard treatment in the Colombian context. **Methods:** A Markov single cohort model was used to simulate the incremental cost per quality-adjusted life-year (QALY) gained every year over a base-case 5-year time horizon. The model considers 5 health states: comorbidity, remission, acute myocardial infarction, stroke, and death. Four comorbidity conditions were evaluated separately: diabetes, hypertension, dyslipidemia, and sleep apnea. The model was evaluated from a third-payer perspective. All costs were expressed in 2016 Colombian pesos ($1.00 = 3051 COP). A 5% annual discount rate was applied to both costs and outcomes. **Results:** In baseline analysis, bariatric surgery was a cost-effective alternative compared with nonsurgical treatment in the diabetes and hypertension cohort with an incremental cost-effectiveness ratio of $6 194 899 and $43 689 527 per QALY gained, respectively. In the sleep apnea cohort, surgery has greater effectiveness and lower costs, which is why it is a dominant strategy. In the dyslipidemia cohort, bariatric surgery is dominated by the nonsurgical approach. **Conclusion:** The current study provides evidence that bariatric surgery is a cost-effective alternative among some cohorts in the Colombian setting. For obese patients with sleep apnea or diabetes, bariatric surgery is a recommendable alternative (dominant and cost-effective, respectively) for the Colombian healthcare system.

Keywords: cost-effectiveness, cost-utility, bariatric surgery, obesity, pharmacologic treatment.

Introduction

Obesity is a chronic, nontransmissible disease from multifactorial etiology; it is generally preventable and, along with overweight, affects at least one-third of the world population.[1] The World Health Organization defines obesity as a health-threatening, excessive fat accumulation in the individual and establishes a classification system in function of the body mass index (BMI) as follows: BMI higher or equal to 25 kg/m^2 is classified as overweight and BMI higher or equal to 30 kg/m^2 is classified as obesity.[2] In Colombia, according to the results of the 2010 National Survey of Nutritional Situation (Encuesta Nacional de la SituaciónNutricional), 16.5% of the adult population is obese (BMI $\geq$ 30), of which 0.9% are morbidly obese (BMI > 40).[3]

Excess weight was previously considered a problem in developed countries but is now also considered a problem in developing countries and has become a manifestation of poverty.[4] The economic impact of obesity is mainly linked to an increase in health expenses, loss of productivity (presentism, absenteeism), decrease of quality of life, and lower life expectancy.[5] In fact, studies carried out in the United States have found that the health-related cost per capita in individuals with obesity is 42.7% higher than normal-weight individuals.[6]

The main obesity treatments include lifestyle changes, such as low-carb diets, low-fat diets, physical activity, and psychological intervention. Pharmacologic treatment is also an option. The US Food and Drug Administration has approved several drugs for the treatment of obesity, such as orlistat, phentermine,

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diethylpropion, benzphetamine, phendimetrazine, lorcaserin, liraglutide, and naltrexone with bupropion.[7,8] In Colombia to date, only orlistat is approved, which according to the clinical practice guidelines is recommended in overweight patients (BMI $\geq$ 27 kg/m^2) with comorbidities or obese patients (BMI $\geq$ 30 kg/m^2) who do not reach therapeutic goals with multicomponent strategies.[7] Nevertheless, the efficacy of these so-called conservative therapies is in discussion because of their low proven weight loss promotion along with diet and physical activity.[9] Bariatric surgery includes a variety of procedures performed to lose weight by reducing the size of the stomach. There is extensive evidence that bariatric surgery is safe and highly effective in reducing weight, obesity-associated comorbidities, and mortality.[10] Although the efficacy of this procedure has been well documented, there is a lack of information regarding its cost-effectiveness in the local context. In the scientific literature, there is a wide variety of economic models that compare bariatric surgery with conventional medical treatment, and when comorbidities have been considered, it has been mostly in patients with diabetes. This evaluation will include other comorbidities attributable to obesity that contribute significantly with its burden of disease. The objective of this study was to estimate the cost-effectiveness ratio of bariatric surgery compared with nonsurgical treatment in high-risk obese patients in Colombia. Among the added values of the model is that for each arm of comparison, different strategies can be used; these have been taken into account, considering both gastric bypass and gastric sleeve in the surgical arm, and both pharmacologic treatment and lifestyle changes (diet and exercise) were considered in nonsurgical management.

Materials and Methods

Choice of Model

The potential target population for bariatric surgery is one that meets any of the following conditions[7]: BMI $\geq$ 40 kg/m^2 with or without comorbidities that could improve with weight loss, and BMI between 35 and 40 kg/m^2 with comorbidities that could improve with weight loss. The model describes the transition of a patient with obesity and comorbidity through different cardiovascular complications, depending on whether he receives bariatric surgery or nonsurgical medical treatment. A patient was modeled with a BMI of 45.6 kg/m^2 and an average age of 40 years.[11]

The model chosen was a combination of decision tree and 4 single-cohort Markov models in which the population corresponds to patients with BMI >35 kg/m^2 with 1 of the following comorbidities: diabetes mellitus type 2, hypertension, dyslipidemia, or sleep apnea. Each comorbidity is analyzed in a separate model. The structure of the model takes into account that patients with comorbidity receiving each intervention may present recurrent health conditions, remission, or a complication derived from their underlying disease whose risk is modified based on the patient's BMI. The model was reviewed and validated with local experts so it could reflect the actual Colombian setting. The first part of the model was a decision tree and the second part was a Markov model (Figure 1).

Five 1-year Markov cycles were used. The time horizon was considered clinically relevant and was selected owing to available efficacy data. The choice of time horizon was made for the following reasons. First, according to the International Registry of Bariatric Surgery and the Standards Committee, there should be a 5-year follow-up of at least 60% of patients to evaluate the results for weight loss, resolution of comorbidities, reduction of complications, and improvement of quality of life.[12] Second, efficacy information related to weight reduction and remission is available for periods of 5 to 10 years, so long-term information is limited. Third, the selected horizon captures the weight gain that may result from postoperative anatomical changes and a reduction in basal metabolism after surgery.[13] Fourth, previous economic evaluations have used 5-year time horizons in their models.[14-16]

Probabilities of transition between states were taken from systematic reviews, randomized clinical trials, and a local governmental database search. References included for the developmental risk assessment of each BMI comorbidity and cardiovascular events in each comorbidity are available in the supplementary material (see Supplemental Materials found at https://doi.org/10.1016/j.vhri.2019.01.010).

Model Assumptions

Every patient in the model has at least 1 comorbidity. Both comorbidity and surgery-related mortality were taken into account in the first part of the model (30 days); after that, only comorbidity-related mortality was included. Acute myocardial infarction (AMI) and stroke-related mortality were considered in the initial 30 days; after that, post-AMI and post-stroke mortality were added to all-cause mortality. Every remission occurs until the second year of follow-up period after bariatric surgery. Risk of stroke and AMI were linked with BMI in the model; however, owing to lack of data for dyslipidemia and sleep apnea, the probability of transition was the same in every cycle regardless of the change in the BMI. Mortality was used by age groups for the general population and for stroke; in the other states, the same mortality was assumed for

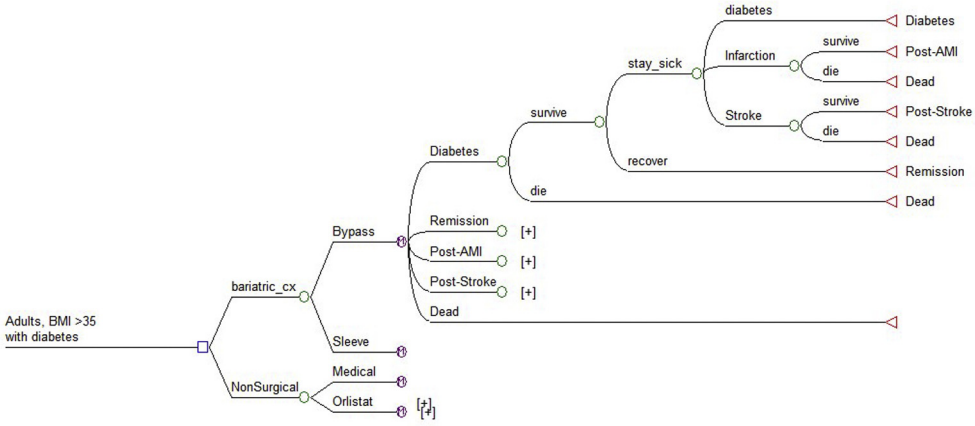

Fig. 1 – Tree diagram of Markov model. AMI indicates acute myocardial infarction.

Table 1 – Model parameters

Variable	Base	Min	Max	Distribution	Source
Utilities					
Major complication utilities	−0.36	−0.4	−0.32	Beta	Klebanoff et al[21]
Minor complication utilities	−0.11	−0.12	−0.1	Beta	Klebanoff et al[21]
1 unit BMI reduction utility	0.0056	0	0.017	Beta	Klebanoff et al[21]
DM2 utility	0.783	0.65	0.885	Beta	GPC DM2[22]
AMI utility	0.88	0.65	0.885	Beta	GPC HTA[23]
Stroke utility	0.63	0.62	0.885	Beta	GPC HTA[23]
Hypertension utility	0.96	0.79	0.98	Beta	GPC HTA[23]
Dyslipidemia utility	0.95	0.95	1	Beta	Newman et al[24]
Apnea utility	0.77	0.73	0.8	Beta	Chakravorty et al[25] Pietzsch et al[26]
Efficacy					
Gastric bypass					
BMI change (year 1)	−14.32	−19.02	−9.62	Beta*	Chang et al[11]
BMI change (year 2)	−12.93	−17.39	−8.47	Beta*	Chang et al[11]
BMI change (year 3)	−16.78	−20.57	−12.99	Beta*	Chang et al[11]
BMI change (year 4)†	−17.86	−22.20	−13.53	Beta*	Chang et al[11]
BMI change (year 5)	−15.93	−20.52	−11.40	Beta*	Chang et al[11]
Diabetes remission	0.9283	0.8529	0.9721	Beta	Chang et al[11]
Hypertension remission	0.7813	0.6367	0.8876	Beta	Chang et al[11]
Dyslipidemia remission	0.6322	0.4086	0.8234	Beta	Chang et al[11]
Apnea remission	0.9468	0.8636	0.9872	Beta	Chang et al[11]
Gastric sleeve					
BMI change (year 1)	−12.14	−14.02	−10.96	Beta*	Chang et al[11]
BMI change (year 2)	−13.39	−19.52	−7.26	Beta*	Chang et al[11]
BMI change (year 3)	−21.88	−27.96	−15.79	Beta*	Chang et al[11]
BMI change (year 4)†	−18.99	−28.09	−9.88	Beta*	Chang et al[11]
BMI change (year 5)	−16.10	−28.22	−3.98	Beta*	Chang et al[11]
Diabetes remission	0.8553	0.7269	0.9407	Normal	Chang et al[11]
Hypertension remission	0.8223	0.6819	0.9201	Beta	Chang et al[11]
Dyslipidemia remission	0.8286	0.6267	0.9455	Beta	Chang et al[11]
Apnea remission	0.9077	0.8006	0.9739	Beta	Chang et al[11]
Nonpharmacologic treatment‡					
BMI change (year 1)	−2.16	0.0000	−5.06	Beta*	Migrone et al[27]
Pharmacological treatment with orlistat					
BMI change (year 1)	−3.13	0.0000	−6.34	Beta*	O'Meara et al[28]
BMI change (year 2)	−2.24	0.0000	−5.42	Beta*	O'Meara et al [28]
Intervention cost					
Previous medical assessment	$616 971	$593 241	$702 398	Gamma	Expert panel
Gastric bypass (procedure)	$6 828 731	$6 771 906	$7 033 298	Gamma	Expert panel
Gastric sleeve (procedure)	$6 277 629	$6 208 381	$6 526 919	Gamma	Expert panel
First year bariatric surgery follow-up	$171 912	$165 300	$195 715	Gamma	Expert panel
2-5 years bariatric surgery follow-up	$85 956	$82 650	$97 858	Gamma	Expert panel
Nonpharmacologic obesity treatment (diabetes)	$525 902	$505 675	$598 719	Gamma	Expert panel
Nonpharmacologic obesity treatment (hypertension)	$525 902	$505 675	$598 719	Gamma	Expert panel
Nonpharmacologic obesity treatment (dyslipidemia)	$572 399	$544 522	$667 446	Gamma	Expert panel
Nonpharmacologic obesity treatment (obstructive sleep apnea)	$999 033	$954 747	$1 153 153	Gamma	Expert panel
Pharmacologic treatment with orlistat 120 mg 3×/day	$574 221	$392 780	$904 005	Gamma	SISMED, obesity GPC[7,29]
Markov states cost					
Diabetes	$1 412 859	$1 291 910	$1 777 439	Gamma	DM2 GPC and experts[22]
Myocardial infarction	$9 339 744	$8 934 999	$10 050 657	Gamma	HT GPC[23] CPI: 1.268
Hypertension	$1 409 415	$1 276 169	$1 817 541	Gamma	Base case
Stroke	$9 714 961	$8 056 718	$24 323 292	Gamma	Castañeda-Cardona et al[30] CPI: 1.206
Dyslipidemia	$796 031	$719 697	$1 029 439	Gamma	Expert panel
Obstructive sleep apnea	$3 229 943	$2 863 406	$3 769 473	Gamma	Expert panel

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Table 1 – *continued*

Variable	Base	Min	Max	Distribution	Source
Bariatric surgery complication costs (not weighed)[§]					
Bleeding	$777 181	$753 849	$861 176	Gamma	Expert panel
Intestinal obstruction	$2 152 358	$2 138 254	$2 203 131	Gamma	ISSS[31]
Cholelithiasis	$2 173 368	$2 159 264	$2 224 141	Gamma	ISSS[31]
Fistulas	$1 482 273	$1 425 263	$1 687 511	Gamma	ISSS[31]
Leakage	$2 602 736	$2 580 170	$2 683 974	Gamma	ISSS[31]
Stenosis	$468 176	$450 169	$533 000	Gamma	ISSS[31]
Iron deficiency	$57 315	$40 553	$96 109	Gamma	SISMED[29]
Vitamin B12 deficiency	$17 802	$10 210	$22 681	Gamma	SISMED[29]

AMI indicates acute myocardial infarction; BMI, body mass index; CPI, Consumer Price Index; DM2, diabetes mellitus type 2; GPC, treatment guideline; HT, hypertension; ISSS, Colombian procedure price database; SISMED, Colombian drug price database.
[*] Distribution was calculated from BMI data.
[†] Change in BMI in fourth year is not reported, so lineal interpolation was made to obtain the result.
[‡] Treatment includes healthcare made by multidisciplinary team, diet, physical activity and lifestyle changes.
[§] Frequency of resource use not included.

comorbidity for all ages. Men and women have the same probability of transition between states. Adverse events were not considered for orlistat treatment because the most frequent events are gastrointestinal, but their intensity has been described as mild to moderate,[17] so costs may be unrepresentative compared with the cost of medication.

Intervention, Comparators, and Outcomes

The intervention was bariatric surgery, which comprises a group of procedures whose election depends on the patient's characteristics, medical criteria, infrastructure, and technical capacity.[7,18] The 2 most frequently used surgical techniques were considered: gastric bypass and gastric sleeve. The comparator was nonsurgical medical treatment that included the treatment of comorbidity, diet and physical activity, and pharmacologic weight reduction therapy. The main health outcome was quality-adjusted life years (QALYs) as recommended by the Colombian health technologies assessment agency (IETS).[19] Utility measures were extracted from the Center for Evaluation of Value and Risk in Health database.[20] Table 1[21-31] shows the different utilities for each state.

Outcomes

For each Markov cycle, BMI change with respect to baseline was considered an efficacy outcome. Data regarding efficacy of bariatric surgery and nonsurgical treatment in weight reduction were obtained by means of a literature review. Information about bariatric surgery efficacy was obtained from Chang et al[11] in a meta-analysis of 37 clinical trials and 127 observational studies. Information regarding orlistat efficacy was obtained from O'Meara et al,[28] and nonsurgical treatment efficacy was obtained from Migrone et al.[27] Efficacy values are presented in Table 1.

Study Perspective, Time Horizon, and Discount Rate

The evaluation was carried out from a third-payer perspective (Colombian Health System), according to the technology assessment agency (IETS).[19] The perspective implies that only direct medical costs were considered. The time horizon was 5 years, considering that this is the follow-up time that at least 60% of obese patients should have, according to the International Bariatric Surgery Registry, to assess correctly the outcomes related with lost weight, quality of life improvement, and resolution of comorbidities.[12] Additionally, the selected time horizon can show the weight regain that usually happens 3 to 6 years after the surgery.[13] In the baseline scenario, a 5% discount rate was used, with 0%, 3.5%, 7% and 12% in the sensitivity analyses.

Cost Estimation

For the identification and quantification of the resources required for the development of bariatric surgery and nonsurgical treatment, local clinical experts were consulted. Drugs, supplies, and procedure costs were obtained from governmental sources.[29,31,32] All costs were expressed in 2016 Colombian pesos ($1.00 = 3051 COP), and costs obtained from literature review were adjusted by price index. Table 1 summarizes the costs used for the model. Supplementary Material comprises the frequency of each bariatric surgery-related complication (see Supplemental Materials found at https://doi.org/10.1016/j.vhri.2019.01.010).

Cost-Effectiveness Analysis

The incremental cost-effectiveness ratio (ICER) of the 2 alternatives (bariatric surgery and nonsurgical medical treatment) used the thresholds of 1 gross national product (GNP) per capita and 3 GNP per capita (2015 per capita GNP in Colombia was $16 613 951). Intervention was considered cost-effective if its ICER was lower than 1 per capita GNP and potentially cost-effective if its ICER was lower than 3. In addition, deterministic and probabilistic sensitivity analysis were performed through Monte Carlo simulations. All analyses were carried out in TreeAge Pro 2009.

Results and Discussion

Bariatric surgery is the most effective treatment in patients with diabetes or hypertension, and the ICER was below the 3 GNP per capita threshold ($49 841 853). In patients with dyslipidemia, effectiveness was similar between bariatric surgery and nonsurgical treatment; nevertheless, because the latter is less expensive, bariatric surgery is dominated. In patients with obstructive sleep apnea there are lower costs and greater effectiveness, so bariatric surgery is dominant. Table 2 shows the results of the evaluation.

Figure 2 shows the effect of different parameters on the cost-effectiveness ratio in tornado analyses. In all cases, minimum and maximum values of time horizon, discount rate, age at model entry, proportion of patients receiving orlistat in the nonsurgical treatment arm, and proportion of patients undergoing bariatric surgery in the bariatric surgery arm were evaluated.

Table 2 – Results of the cost-effectiveness analysis for the base case

Strategy	Cost	Incremental Cost	Effectiveness (QALYs)	Incremental effectiveness	Cost-effectiveness ($/QALYs)	ICER
Diabetes						
Bariatric surgery	$22 930 361	$2 782 563	4.454	0.449	5 147 820	6 194 899
Nonsurgical	$20 147 798		4.005		5 030 394	
Hypertension						
Bariatric surgery	$16 716 091	$5 868 508	4.654	0.134	3 591 882	43 689 527
Nonsurgical	$10 847 583		4.520		2 400 158	
Dyslipidemia						
Bariatric surgery	$14 196 316	$6 131 190	4.448	−0.0392	3 191 763	Dominated
Nonsurgical	$8 065 127		4.487		1 797 455	
Obstructive sleep apnea						
Bariatric surgery	$19 281 618	$2 007 062	3.981	0.354	4 842 856	
Nonsurgical	$21 288 680		3.628		5 868 663	Dominated

ICER indicates incremental cost-effectiveness ratio; QALY, quality-adjusted life year.

The tornado diagram shows 4 additional variables that affect cost-effectiveness in each cohort modeled. In the modeling of patients with diabetes and obesity, the variables that have the greatest impact on the ICER are the temporal horizon and the cost of the stroke; however, bariatric surgery is maintained as a cost-effective or dominant alternative. In the modeling of hypertensive patients with obesity, the variables that most modify the ICER are the utility for reduction in the BMI of 1 unit followed by the temporal horizon and mortality at 30 days in patients submitted to gastric sleeve. For the variables considered in the model, bariatric surgery can be cost-effective in this cohort but not dominant. In dyslipidemia with obesity, the variable that has the greatest impact on the ICER is the utility associated with the reduction in BMI because bariatric surgery would go from dominated to potentially cost-effective. In the model of patients with obstructive sleep apnea and obesity, the results of the base case remain robust because the surgery is cost-effective or dominant with respect to nonsurgical treatment.

Deterministic sensitivity analysis was carried out by modifying the discount rate to 0%, 3.5%, 7%, and 12% in every cohort of patients. In patients with diabetes, the ICER was under the threshold in all cases; in the hypertension cohort, the ICER with discount rates of 7% and 12% exceed the threshold of 3 GNP per capita; in dyslipidemia, bariatric surgery is dominated by nonsurgical treatment in all cases, and in sleep apnea, bariatric surgery is dominant in all cases. Comparing bariatric surgery with nonpharmacologic medical treatment, bariatric surgery remains a cost-effective alternative in diabetes and dominant in apnea but is not cost-effective in hypertension and dominated in dyslipidemia. Nevertheless, when compared with orlistat, bariatric surgery is a cost-effective alternative in diabetes, hypertension, and dyslipidemia and continues to be dominant in the cohort of patients with apnea. These results are explained by the additional benefits in remission and reduction of cardiovascular risk from the change of step, in contrast with the lower effectiveness of the drug and the additional cost of nonpharmacologic medical treatment.

Probabilistic sensitivity analysis was carried out with the data of the distribution of all variables by performing a Monte Carlo simulation with 1000 iterations. Nonsurgical treatment was set as baseline. In the diabetes cohort, bariatric surgery is a cost-effective alternative in 81% of the cases and is a dominant alternative in 18% of the cases; only in 0.7% of the cases the ICER was above the willingness-to-pay threshold. In hypertension, the ICER was below the threshold in 54% of the cases and above the threshold in 38% of the cases; in 7% of cases, bariatric surgery can be a dominated alternative. In the dyslipidemia cohort, bariatric surgery was dominated by nonsurgical treatment in 75% of the iterations; in 25% of the cases bariatric surgery is a more costly and more effective option, but its ICER is above the threshold. The results obtained in hypertension could be explained by the risk measures of AMI and stroke obtained from the literature in which the risk is slightly higher in patients with a lower BMI, which some authors have called the obesity paradox.[33] Although the mechanisms are not fully understood, it is possible that hypertensive patients with obesity have lower vascular resistance and plasma renin activity than hypertensive patients with lower body weight, and these mechanisms may contribute to their better prognosis.[34] The increased risk in lower BMIs reduces the difference in QALYs between bariatric surgery resulting in greater weight loss than nonsurgical medical treatment. Nevertheless, the accuracy of BMI in defining obesity has also been questioned, and publication bias has been documented.[35] Although the measure used has limitations and may underestimate the benefits of bariatric surgery, this intervention remained a cost-effective option in most simulations.

The results obtained in dyslipidemia are due to the small difference in quality of life between bariatric surgery and nonpharmacologic treatment on the horizon of analysis. This small difference in quality of life is related to the fact that the analysis considers individual risks and not multiple risks, so that in the population with dyslipidemia the risk of presenting AMIs or strokes is lower than that documented in patients with diabetes or hypertension. Finally, in sleep apnea patients, bariatric surgery was a dominant alternative in 74% of the cases and is cost-effective in 26%. Supplementary material shows the results of Monte Carlo simulation in every cohort (see Supplemental Materials found at https://doi.org/10.1016/j.vhri.2019.01.010).

The proposed Markov models assess the cost-effectiveness of bariatric surgery in different cohorts of patients with obesity and cardiovascular risk in a time horizon that reflects high-impact economic outcomes such as acute myocardial infarction and stroke. Several economic models have compared bariatric surgery with other treatments [14,15]; however, most of these studies were performed on a diabetic population. In other investigations carried out in the cohort of patients with diabetes, gastric bypass has shown to be cost-effective with respect to nonsurgical medical treatment. Ackroyd et al[36] estimated an ICER of £1517 per QALY, whereas for Picot et al[14] the ICER of bariatric surgery compared with nonsurgical treatment was £4580 per QALY gained for a 5-year time horizon and £1367 per QALY for a 20-year time horizon, being cost-effective for a willingness-to-pay threshold of £20 000 for QALY gained. In another evaluation developed in

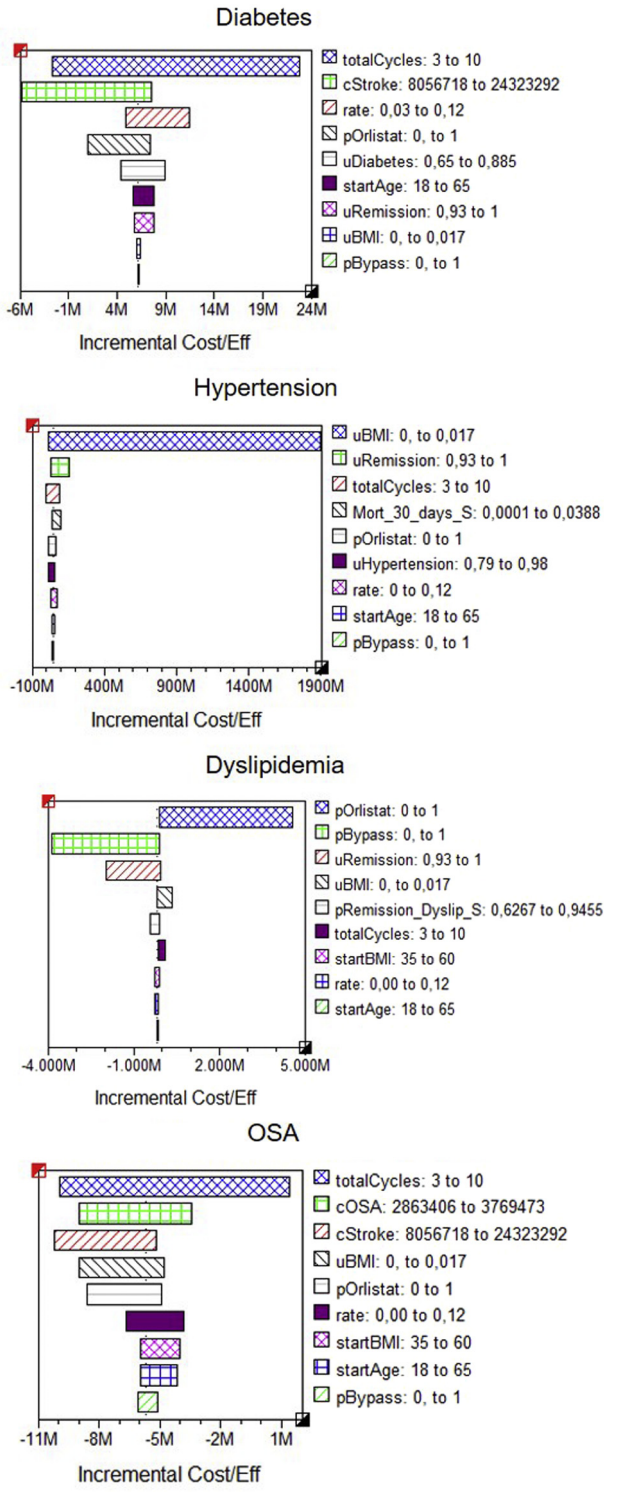

Fig. 2 – Tornado diagrams of comparison bariatric surgery vs nonsurgical treatment. BMI indicates body mass index; OSA, obstructive sleep apnea.

Mexico, where there is a high prevalence of obesity, they applied a simulation model of discrete events and found a reduction in total costs in the bariatric surgery group compared with nonsurgical medical treatment in a 10-year horizon analysis, particularly a reduction in the costs of treatment of type 2 diabetes, hypertension, and hypercholesterolemia.[37]

This research presents additional analyses to those presented in the economic evaluation developed in the framework of the Colombian clinical practice guidelines for the treatment of obesity in adults, which used a discrete event simulation model for patients with diabetes mellitus or hypertension who could develop different complications related to overweight and obesity. They estimated that the intervention would have a gain of 2.15 additional years of life with an ICER for QALY gained of $7 738 151.[7]

The greatest limitations of this study were the assumptions made and the lack of local information regarding efficacy data and utility measures and that comorbidities were modeled individually; however, obese patients can suffer more than 1 comorbidity at the same time. Data extracted from the Chang et al meta-analysis correspond to data of a population whose average BMI was 46.5 kg/m^2.[11] For the purposes of this study, it was assumed that weight reduction has a similar behavior in the range of 35 to 60 kg/m^2. Weight regain was not modeled as an independent variable but as a feature related with BMI, and it was recalculated in each cycle for each intervention.

Analyses indicate that bariatric surgery can be a cost-effective intervention even under a short time horizon because, in addition to the efficacy documented in several clinical studies, it has greater benefits in quality of life and cost reduction in a population at high cardiovascular risk. These results are relevant in the Colombian context, where obesity has been increasing and has a high impact in disease burden. The results obtained indicate that bariatric surgery may present greater benefits in certain comorbidities, which is why this should be a criterion to be considered in the patient prioritization process.

Acknowledgments

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Supplemental Material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.vhri.2019.01.010.

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