VALUE IN HEALTH REGIONAL ISSUES 1 (2012) 172–179

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/vhri

Economic Evaluation of Bariatric Surgery in Mexico Using Discrete Event Simulation

Olivo Omar Zanela, MSc[1,], Hermilo Arturo Cabra, MSc[1], Guillermo Meléndez, MD[2], Pablo Anaya, MSc[2], Frederic Rupprecht, MSc[3]*

[1]*Johnson & Johnson de México, S.A.de C.V., Mexico City, México;* [2]*Fundación Mexicana para la Salud, Mexico City, México;* [3]*Ethicon Endo-Surgery, Inc., Cincinnati, OH, USA*

ABSTRACT

Objectives: Morbid obesity represents high costs to health institutions in controlling associated comorbidities. It has been shown that bariatric surgery resolves or improves comorbidities, thus reducing resource utilization. This analysis estimated the total costs of treating morbid obesity and related comorbidities through conventional treatment compared to bariatric surgery under the Mexican public health system perspective. **Methods:** An economic evaluation model was developed by using discrete event simulation. One hundred fifty patients were created in each arm, with considered comorbidities allocated randomly. Preoperative comorbidity prevalences and bariatric surgery's efficacy for resolving them were obtained from published literature. Comorbidity treatment costs were obtained from the 2007 Mexican Institute of Social Security diagnosis-related group list and publications from the National Institute of Public Health. Only 12 patients were operated each month on the surgical arm. Complications associated with comorbidities were not considered. The considered time frame for simulation was 10 years, with a 4.5% annual discount rate. **Results:** Return on investment, or cost breakeven point, for bariatric surgery was obtained after 6.8 years. Total costs for the surgical group were 52% less than conventional treatment group costs after 10 years. Bariatric surgery reduced the cost of treating type 2 diabetes, hypertension, and hypercholesterolemia by 59%, 53%, and 65%, respectively. Return on investment for bariatric surgery in patients with type 2 diabetes as the only comorbidity was 4.4 years. **Conclusions:** Despite conservative assumptions, investment in bariatric surgery is recouped in 6.8 years, generating relevant potential savings in the treatment of morbidly obese patients. In high-risk subpopulations, return on investment time is shorter.

Keywords: bariatric surgery, discrete event simulation, economic evaluation, Mexico, morbid obesity, return on investment.

Introduction

The growing prevalence of excess weight (body mass index [BMI] $\geq$ 25 kg/m^2) and obesity (BMI $\geq$ 30 kg/m^2) observed worldwide in the last 20 years is a major cause of concern for health systems because of their significant economic and social burden [1]. Surveys and investigations from various countries have shown a general upward trend in the prevalence of morbid obesity (BMI $\geq$ 40 kg/m^2). In the United States, one in five obese people is morbidly obese [2]; in Australia, morbid obesity has increased fourfold in the last 20 years [3]; in Chile, the National Health Survey showed that the prevalence of morbid obesity was 1.3% [4]. For Mexico, the prevalence of morbid obesity was 1.9%, according to the National Health Survey in 2000 [5].

Morbid obesity is associated with higher mortality and lower quality of life (QOL) than that reported by normal weight patients: death rates are 2 to 12 times higher [6], and health-related QOL is poorer, as morbidly obese patients report being worse-off in their breathing, sleep, mobility, and sexual activity [7]. Obesity-related comorbidities are highly prevalent among this subpopulation: Buchwald et al. [8] reported that 22.3% had type 2 diabetes (T2D), 41.0% had hypertension, and 35.7% had dyslipidemia.

The growing prevalence of morbid obesity represents a greater demand of resources on health systems. In the United States, it was estimated that the direct medical costs of morbidly obese patients were 60% greater than those incurred by patients with normal weight [9]. Patients with a BMI of more than 35 kg/m^2 represented 37% of the obese population and consumed 61% of the resources [10], while the annual cost of treating an overweight patient was less than half of that incurred by a morbidly obese patient [11]. It was estimated that the costs of obesity corresponded to 4.1% of the total health care costs in Canada [12], while the medical costs associated with obesity in the United States were US $147 billion [13]. For Mexico, there is no published evidence of how much morbid obesity costs the health system, and such information would be valuable for treatment and reimbursement decision making.

Because of its favorable results, bariatric surgery has generated more interest, leading to a significant increase in the number of procedures performed. It is estimated that 344,221 bariatric surgeries were performed in 2008 [14], with the most common procedures being laparoscopic adjustable gastric

Conflicts of interest: The authors have indicated that they have no conflicts of interest with regard to the content of this article.

* *Address correspondence to:* Olivo Omar Zanela, Javier Barros Sierra 555 1st Floor, Santa Fe, México, D.F. 01210, México.

E-mail: ozanela@its.jnj.com.

2212-1099 – see front matter Copyright © 2012, International Society for Pharmacoeconomics and Outcomes Research (ISPOR). Published by Elsevier Inc.

http://dx.doi.org/10.1016/j.vhri.2012.09.012

band (42.3%) and Roux-en-Y gastric bypass (39.7%). It is worth mentioning sleeve gastrectomy, a new surgical technique that has been gaining popularity because of its simplicity and good short- and midterm outcomes [15].

As an alternative to conventional treatment, bariatric surgery has shown better results in reducing excess weight and improving QOL. Weight loss with conventional treatment is moderate and seldom sustained [16]; in contrast, bariatric surgery results in a 53.82% excess weight loss after 2 years [8], yielding greater weight loss and improved QOL than conventional treatment [17].

Bariatric surgery reverses, eliminates, or significantly reduces comorbidities, such as T2D, arterial hypertension (AHT), and hypercholesterolemia (HCL). It has been shown that bariatric surgery resolved or improved T2D and AHT in morbidly obese patients in 87% and 79% of the cases, respectively [8,18]. The Swedish Obese Subjects (SOS) study, an ongoing, nonrandomized, matched, prospective, and controlled trial, with a median follow-up of 14.7 years, has shown that bariatric surgery is an effective intervention to achieve sustained weight loss, while treating and preventing obesity-related comorbidities; the authors also found that bariatric surgery is associated with fewer cardiovascular deaths and total first-time cardiovascular events than conventional treatment [19].

Bariatric surgery is a cost-effective intervention to treat morbid obesity when compared to nonsurgical treatment, with incremental cost-effectiveness ratios within acceptable ranges when evaluated in different settings [20–22]. Crémieux et al. [23] showed that the investment in these surgical procedures is returned between 2 and 4 years after it was performed, while Mullen and Marr [24] found that the return on investment (ROI) point of gastric bypass is 3.5 years.

Economic evaluation of health care interventions is typically performed by using models based on the behavior of cohorts of patients (decision trees, Markov models), but they have their limitations, as they generally assume normally distributed averages of certain patient characteristics and no correlation between them. As well, cohort-based models are based on memoryless features and do not allow for the simultaneous development of multiple events and/or the transition to multiple health states. Works such as that by Caro et al. [25] indicate the need to develop models for the economic evaluation in health care considering the individual behavior of patients, allowing for patient heterogeneity, multiple resource utilization, and individual outcomes based on individual clinical history.

In models based on discrete event simulation (DES), it is possible to assign characteristics to patients on an individual and random basis, so as to establish and quantify the relationship between their baseline characteristics and the events or interventions they undergo [26]. DES allows to study systems and processes whose states change over time, to model the natural clinical course of a disease and its management in terms of the events that can occur during the process, and to quantify the use of resources (such as consultations, drugs, and diagnostic tests). DES also enables resource restriction, such that the actual conditions of health systems (surgical capacity, waiting lists) are clearly expressed. As morbid obesity is a chronic condition, the use of DES could provide a realistic approach to model the disease, its treatment alternatives, and its consequences.

The objective of this study was to estimate the ROI time, or cost breakeven point, for bariatric surgery in patients with morbid obesity with one or more of the three most common comorbidities, from the perspective of the Mexican public health system, by means of a DES model.

Methods

A model for the economic evaluation of morbid obesity was developed by using DES because of its advantages in terms of controlling and assessing the history of each patient and estimating the ROI point [27].

To reflect the current local public health care setting, 150 patients were created, to whom comorbidities (T2D, AHT, and HCL) were assigned randomly, according to the prevalences for morbidly obese patients reported by Buchwald et al. [8] (Table 1). It was assumed that all created patients were adult, at least grade II obese (BMI $\geq$ 35 kg/m^2), had at least one comorbidity, and had been previously and unsuccessfully treated with nonsurgical treatment, as established by European and local guidelines [28,29]. It was assumed that comorbidity prevalences were independent, as there is no local information on crossed-prevalences for the targeted population.

In the model, two comparison arms were included: 1) without surgical intervention (control arm) and 2) with surgical intervention (bariatric surgery arm). Once a patient (and his or her clinical profile) was created, he or she was cloned so that each arm had an identical cohort in terms of patients and comorbidities. Comorbidities in both arms were treated pharmacologically from the start of the simulation, while their associated complications were not considered.

Only 12 patients were operated each month on the surgical arm. This operative restriction is the source of the waiting list patients face in real conditions; while waiting their turn for surgery, they received pharmacological treatment for their comorbidities, thus quantifying waiting list costs. All surgical procedures were assumed to be performed at a certified center of excellence, with low complication and mortality rates as suggested by literature [30], and thus not considered in the evaluation. No learning curve for surgeons was assumed, thus assuming that they yielded the same results in all operations.

In published reports [8,18,31], comorbidity resolution occurs after surgery; however, each comorbidity is resolved at a different rate over time [32], while there is a percentage of patients who, despite not presenting the comorbidity at the time of surgery, develop it over time. The resolution and re-incidence percentages of comorbidities were taken from Buchwald et al. [8,18] and the SOS study [31,33], given that this is the most complete information set available for the analyzed arms. For the purposes of the model, the annual prevalence of each considered comorbidity was determined by Eqs. 1 and 2:

$$\text{Prev}_{t=2} = \text{Prev}_{t=0}[1-\text{Recovery rate}_{t=2}] + \text{Incidence rate}_{t=2}[1-\text{Prev}_{t=0}] \quad (1)$$

$$\text{Prev}_{t=10} = \text{Prev}_{t=0}[1-\text{Recovery rate}_{t=10}] + \text{Incidence rate}_{t=10}[1-\text{Prev}_{t=0}] \quad (2)$$

where Prev refers to the prevalence of each comorbidity, t refers to the year in which the prevalence is estimated, recovery rate refers to the rate of resolution of the comorbidity, and incidence rate refers to the rate at which patients develop the comorbidity during the simulation.

The temporal end points included in the model correspond to the interpolation of prevalences for years 0.5 and 1 (according to

Table 1 – Preoperative comorbidity prevalences.

Comorbidity	Preoperative prevalence (%)	Source
Type 2 diabetes	22.3	Buchwald et al. [8]
Hypertension	41.0	Buchwald et al. [8]
Hypercholesterolemia	27.9	Buchwald et al. [8]