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### Modelling the long-term outcomes of bariatric surgery: A review of cost-effectiveness studies



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#### A B S T R A C T

Obesity, defined as BMI  $\geq 30$  kg/m<sup>2</sup>, affects over 30% of the United States adult population and has been declared an epidemic by the Centers for Disease Control. Bariatric surgery is a treatment option to reduce excess weight and is available to individuals with BMI greater than 40 kg/m<sup>2</sup>, or 35 kg/m<sup>2</sup> with obesity-related comorbidities. As surgical options have become more common, researchers have analysed the long-term cost-effectiveness of these procedures. However, the follow-up data on patients is limited, and modelers need to forecast lifetime costs and outcomes for this chronic disease. In this chapter, we conduct a systematic literature review of cost-effectiveness studies on bariatric surgery to understand the forecasting methods used in practice. We identified six unique studies, which used statistical models, Markov models, or assumptions to forecast lifetime outcomes. We discuss each of the approaches, so clinicians, policy-makers, and payers can make informed interpretations based on the models.

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#### Introduction

Obesity, defined as body mass index (BMI)  $\geq 30$  kg/m<sup>2</sup>, affects nearly 36% of the adult population in the United States and has been growing in other countries as well [1,2]. The prevalence of morbid obesity (BMI  $\geq 40$  kg/m<sup>2</sup>) has risen from 0.02% to 2% of the population from 1986 to 2000 [3]. The Centers for Disease Control declared obesity to be an epidemic that is common, serious, and costly. Until recently, lifestyle changes were the main recommendation for obese individuals.

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In the past decade, there has been an increase in the availability and utilization of bariatric surgical procedures, which aim to provide a permanent solution to the morbidly obese. These procedures include open Roux-en-Y gastric bypass surgery (ORYGB), laparoscopic Roux-en-Y gastric bypass surgery (LRYGB), laparoscopic adjustable gastric banding (LAGB), and laparoscopic sleeve gastrectomy (LSG). These procedures alter a patient's digestion by cutting, removing, or restricting his or her digestive system. It is estimated that 220,000 people in the United States underwent bariatric surgery in 2008 compared with 63,100 in 2002 [4].

ORYGB and LRYGB procedures reduce the size of the stomach by stapling the stomach and then attaching a pouch to the small intestine bypassing the rest of the stomach. ORYGB is done with an incision near the abdomen while LRYGB is done with a laparoscope, which reduces recovery time [5]. LAGB is a procedure where a band is placed around the top portion of the stomach effectively making the stomach smaller [5]. LSG is performed by surgically removing parts of the stomach to reduce it to approximately 25% of its original size [6].

As the use of bariatric surgical procedures become more common, the number of cost-effectiveness analysis (CEA) studies has also increased. Our literature search produced 49 papers published between five and ten years ago and 100 different papers published in the last five years. Bariatric surgery is considered a permanent solution for long-term weight-loss, and excess weight has been associated with myriad complications whose risks factors may change over time [7]. One would need to model the long-term outcomes associated with bariatric surgery to capture the influence of excess weight loss on health outcomes. On the cost side, these surgical procedures can be considered a lifetime investment with a high upfront cost resulting in subsequent lower costs associated with comorbidity resolution.

The main objectives of this study are to provide a summary of recent cost-effectiveness models on bariatric surgery and to understand how researchers model the long-term outcomes of obesity, a chronic disease with limited data. Then, we will evaluate the different techniques utilized by the authors of CEA studies in bariatric surgery to model long-term outcomes. Previous literature has modelled long-term associations between obesity and mortality [8,9]. Others have analysed the relationship between excess weight and comorbidities [10]. The scope of this paper is to focus on studies that relate directly to bariatric surgery and not just obesity in general.

## Methodology

To find the CEA models of bariatric surgery to include in our analysis, we conducted a literature search based on published studies. Our search results included articles in PubMed by searching for 'cost-effectiveness' and 'bariatric surgery'. We filtered our results to include only articles published in the past five years, in English, with abstracts, and with original models. Because of the limited real-world data on LAGB patients and since we wanted to identify studies reflecting the current basket of bariatric surgery options, we limited the inclusion criteria to five years. To prevent duplication of search results, we excluded meta-analyses and systematic reviews, which did not have original models. A detailed diagram of the search is shown in Fig. 1.

For our evidence table, we identified parameters and outputs of each study of importance and interest to clinicians, payers, and outcomes researchers. These included the setting, comparators, model timeframe, model type, data sources, discount rate and results.

The setting was the country or context at which the study was targeted. The study comparators column lists the interventions and the standard of care in each study. Model timeframe is defined as the number of years the cost-effectiveness study lasts. Data source identifies origin of the cost, safety, and efficacy data used to construct the model. The discount rate describes the rate at which future costs and utilities are discounted in the model. The results variable includes the incremental cost-effectiveness ratios (ICERs) of the CEA studies, which is computed as the ratio between the difference in costs vs. the difference in outcomes between the intervention and the standard of care. Lastly, we categorize the forecasting approaches of the papers into broad categories.

## Results

Fig. 1 provides a summary of the literature search results. The initial search, 'Bariatric Surgery' and 'Cost-Effectiveness', returned 169 results, which was reduced down to 91 articles after filtering for

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