Chapter 2
Cost of Obesity Recurrence

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Abstract  Bariatric surgery allows patients to lose a substantial proportion of their excess body weight; however, over time this weight may slowly return. This chapter will discuss the financial impact of obesity and its management through surgical intervention, as well as the rate of weight recurrence after bariatric surgery. The mechanistic and patient behavioural causes of this weight regain will be discussed. Revisional procedures are the current approach to modifying obesity recurrence, and various management options will be reviewed. Additionally, the costs of this endeavour, as well as the tools for evaluating costs and the economic impact of bariatric surgical revision, will be explored.
2.1 Introduction

Obesity is an epidemic, and the associated comorbidities are well known. Deducing the costs of this major enterprise remains a significant challenge.

While the problems are plentiful, resources are scarce in public healthcare systems. Choices regarding allocation of restrictive healthcare resources are a necessary obstacle to treating this spectrum of disease. In Canada’s public healthcare system, obesity treatment extends beyond managing current finite resources, and involves protecting future coffers, from the expensive results of lifetimes of obesity.

One of the realities of bariatric surgery is a subset of postoperative patients who will regain weight (Courcoulas et al. 2013). This is considered to be a failure of the original bariatric procedure. When obesity recurs, patients are faced with new challenges, and often seek advice from a bariatric surgery team for further management. There are multiple options for a patient experiencing obesity recurrence, ranging from doing nothing to performing another bariatric surgery, commonly referred to as revision surgery. Understanding where the expenses lie, not only in obesity but also in the treatment of it (including behavior recidivism, weight regain, and surgical complications), allow healthcare decision makers to optimize resource use.

The cost of obesity has been tracked globally over the past two decades. However, updated information is difficult to find. While the cost-effectiveness of bariatric surgery has been studied in length, few studies look at the long-term or lifetime financial impacts of surgery and weight regain. Information on the cost of revision procedures or comorbidity recurrence is incomplete and a challenge to locate. Inconsistencies exist between countries and institutions, while other data points are not readily available or published.

2.2 Cost of Obesity

2.2.1 Identifying Types of Cost Analysis Within Bariatric Literature

Cost analyses exist in a spectrum, from simple calculations to multifactorial summative evaluations. While the complexities are generally formulated by a health economist, certain key terms and concepts are important for understanding obesity costs, including those for revisional care and surgery.

In the case where a cost is determined without comparing alternatives to the program/service being addressed, the study is a cost description. While arguably the simplest form of evaluation, a cost description can provide valuable information, or impact to a bariatric program regarding a service. Sheppard et al. conducted
a cost description study, which to date is the only publication that includes the cost of revision surgery and weight regain (Sheppard et al. 2013).

To advance the breadth of the evaluation, multiple alternative actions with the same intended outcome, for instance, bariatric surgery and nonsurgical weight loss programs, can be compared. The analysis can be conducted from a variety of angles. If the evaluation contrasts the intended outcomes of the alternatives, i.e., weight loss, the study is an efficacy evaluation. If the cost of both programs is differentiated, without comparing clinical outcomes, the study is a cost-analysis.

All of these methods are considered partial healthcare evaluations. A full economic evaluation combines aspects of all aforementioned: it evaluates multiple alternatives, both with regard to outcomes and cost. A full evaluation can be further categorized as a cost-effectiveness analysis, cost-utility analysis, or a cost–benefit analysis. In a broad sense, analyses for guiding resource allocation decisions include cost-effectiveness analysis and cost-utility analysis. Studies that aid in determining appropriate budget expansion to adopt or include a program, or to illustrate the benefit of a program, are often cost–benefit analyses (Drummond et al. 2005).

A cost-effectiveness analysis deals with an individual consequence, that each of the alternative programs has in common: in our example, weight loss. This common outcome has an associated cost, and the programs can be compared on the basis of the cost of this outcome: for example, cost per kilogram excess weight loss.

While often a single outcome and its associated costs are adequate for a study, it can be useful to measure the preferences that the study population/participants have regarding the outcome of alternative programs. For instance, two patients, one a mail carrier and another an office administrator, each lose 40 kg of excess weight. While the outcome is the same for both, one may consider the weight loss beneficial, to earning a living and reducing the risk of injury at work: the other may not see these same rewards. Thus, the utility of the same outcome differs. A cost utility analysis expresses the cost for each unit of quality of life gained. Usually, these units are expressed as quality-adjusted life years, i.e., QALYs (McCabe 2007).

Cost–benefit analysis measures the outcomes and costs of programs/actions and expresses both as a summative monetary value. By providing a net cost, either positive or negative, for a program, this evaluation can aid decision makers, in adopting or rejecting programs based on their overall benefit and impact.

A well-conducted economic evaluation provides relevant alternatives and illustrates the effectiveness. Moreover, all relevant costs and benefits are expressed in an appropriately adjusted monetary value, or discount rate, to allow for variation in currency value, or inflation over the time frame of the study.

### 2.2.2 The Cost of Obesity

The terms direct versus indirect costs are helpful, in the conceptualization of obesity surgery and its costs. Some experts state these terms foster confusion, as
there are no clear inclusion criteria for direct cost. What one writer may include in the catchall term “indirect cost,” another may have completely omitted. Caution is required when utilizing these terms, as part of a toolkit for conceptualizing the cost of obesity, revision surgery, etc., and care should be taken when interpreting studies that calculate “indirect costs” (Jacobs and Fassbender 1998).

When conducting or reviewing a study, our team considers in-hospital, outpatient clinic, pharmacologic costs, and costs of major comorbidities to be direct costs. We include diabetes, hypertension, sleep apnea, and dyslipidemia as major comorbidities. Indirect costs include but are not restricted to disability, loss of productivity/worktime/employment, and private out-of-pocket expenses such as travel, family/caretaker time, private insurance, and non-publically funded healthcare expenses.

Several countries have calculated the annual cost of obesity on their healthcare system, with varying methodologies and inclusion criteria for indirect and direct costs (Colagiuri et al. 2010; Lancy and Gruen 2013; Bahia et al. 2012; Anis et al. 2010; Corscadden et al. 2011; Scottish Government 2010; Tigbe et al. 2013; Finkelstein 2001; Cawley and Meyerhoefer 2012) (Table 2.1).

The United States remains the most expensive country to receive medical care, and has the highest expenditures for obesity management. As of 2012, the United States draws on 21% of their healthcare costs to manage obesity (Cawley and Meyerhoefer 2012). In 2006, obesity expenditures were estimated to be 4.1% of Canadian health expenses (Anis et al. 2010). Obese Americans were said to cost

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<th>Table 2.1 Annual cost of obesity to the healthcare system</th>
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*aColagiuri et al. (2010)*
*bLancy and Gruen (2013)*
*cBahia et al. (2012)*
*dAnis et al. (2010)*
*eCorscadden et al. (2011)*
*fScottish Government (2010)*
*gTigbe et al. (2013)*
*hFinkelstein (2001)*
*iCawley and Meyerhoefer (2012)*
$1,429 USD more for healthcare than normal weight individuals (Cawley and Meyerhoefer 2012). Additionally, a United States report determined that by 2018, $344 billion would be spent on healthcare costs to manage obesity (Thorpe 2009).

### 2.2.3 Cost-Effectiveness of Bariatric Surgery

Globally, more than 340,000 bariatric procedures are performed annually, with one-third of those procedures performed in the United States. In Canada alone, an estimated 6,000 bariatric surgeries were performed in 2012, representing a 280% increase in 6 years (Canadian Institute of Health Information 2014). These surgeries cost the Canadian healthcare system approximately $48 million in 2012. In the Canadian province of Alberta, the cost of laparoscopic adjustable gastric band (LAGB), laparoscopic sleeve gastrectomy (LSG), and laparoscopic Roux-en-Y gastric bypass (LRYGB) is $10,500, $12,000, and $18,000 CAD, respectively. The total rate for early and late complications is 12.4%. Across Canada, early to intermediate complication rates are 5.3% (Canadian Institute of Health Information 2014). An average of $475 CAD per patient is spent managing postoperative complications, including band removal, ulceration, hemorrhage, staple line leak, anastomotic stricture, and internal hernia. These patients also attend a multidisciplinary clinic, in preparation for surgery, attributing an additional $500 CAD cost. In total, Canadian bariatric surgery can cost $11,475–$18,975 CAD per patient (Sheppard et al. 2013, 2014a, b). The average cost of bariatric surgery within the United States is significantly more expensive at $24,000 USD (Mehrotra et al. 2005; Cremieux et al. 2008).

Regardless of a front-loaded cost of $10,000–$25,000, bariatric surgery has been established as a cost-effective strategy for treating obesity. Bariatric surgery reduces comorbidity management costs by more than half, and monthly savings of $900 USD per patient between 13 and 24 months (Cremieux et al. 2008; Sussenbach et al. 2012). Postoperative pharmaceutical savings of $180 USD/month can be expected (Monk et al. 2004). In Scotland, a noticeable decrease of 40% in total pharmaceutical costs was seen, 24 months after bariatric surgery. The pharmaceutical cost for managing diabetes alone decreased by 78% (£4,500–£1,000). Both hospitalization and medical services significantly decreased in cost after surgery (Karim et al. 2013).

Cost-effectiveness is measured by calculating the incremental cost effectiveness ratio (ICER), which contrasts incremental costs with incremental health benefits (increased years of life). When comparing health interventions (e.g., surgery vs. nonsurgical management of obesity), a lower ICER indicates the same unit of outcome can be achieved at a lower cost (Institute of Health Economics 2012). Incremental cost–utility ratio (ICUR) involves incorporating QALY into the cost-effectiveness calculation. The Canadian Agency for Drugs and Technologies in Health (CADTH) determined that all primary bariatric procedures, compared to
nonsurgical treatment over a life span, corresponded with an ICUR ranging from $6,500–$12,000 per QALY (Klarenbach et al. 2010).

Bariatric surgery has been determined to be cost-effective on a global level. A study from the United Kingdom found that the ICUR for LRYGB and LAGB, compared to standard care, was £1,500 and £1,900, respectively. The ICER over 20 years was £3,500–£12,800 for LRYGB and LAGB; however, over 2 years LAGB had an ICER of £60,800 (Klarenbach et al. 2010). A study in Portugal observed an increase of 1.9 QALY compared to medical intervention and a savings of €13,000 per patient (Faria and Preto 2013).

In the United States, an ICUR of $5,400 USD–$16,000 USD for women, and $10,700 USD–$35,600 USD for men, was calculated after gastric bypass (Klarenbach et al. 2010), and an ICER over a lifetime of $6,600 USD and $6,200 USD per QALY gained, for LRYGB and LAGB, respectively (Wang and Furnback 2013). Another American study determined that the ICUR after 10 years, would be $21,600–$38,000 per QALY, or $9,400–$12,000 per QALY over a lifetime, for LRYGB and LAGB (Klarenbach et al. 2010). The United States remains one of the most expensive healthcare systems in the world, yet the cost-effectiveness of bariatric surgery, compared to standard care, is equivalent across countries.

The bypass dominates as the most cost-effective weight loss option for obese type II diabetics. Hypertension and diabetes are by far the more expensive and prevalent comorbidities, together totaling an annual cost of nearly $2,300 USD per patient in pharmaceuticals. Cost savings after bariatric surgery account for a reduction in two-thirds of medical expenses associated with obesity (Maggard et al. 2005).

### 2.3 Recurrence Rate

Weight regain occurs in 10–20 % of patients after approximately 36 months post-bariatric surgery (Sheppard et al. 2013). Different philosophies exist, as to whether weight recidivism is due to a lack of behavioral lifestyle change or simply a mechanical failure of the procedure (de Gara and Karmali 2014). Several methods exist for managing such patients. These include revisional surgery, endoscopic interventions, and medical management. The frequency of undergoing revisional surgery ranges from 2.5 to 18.4 % (Sheppard et al. 2013). Inevitably, these surgeries have higher complication rates than primary surgery (Worni et al. 2013). As such, revisional surgery due to weight regain comprises a long-term direct cost to the healthcare system that has yet to be quantified.
2.4 Causes of Revision Surgery

There are several major causal factors for patients to seek or require revisional surgery. Weight regain is one of the more common long-term reasons for requesting revisional surgery.

2.4.1 Weight Recidivism

Weight recidivism has become a major concern after bariatric surgery. Long-term studies show that over time, patients slowly regain weight, and upwards of nearly 15% will fail to lose an excess weight loss of 50% or more, after 5 years (Magro et al. 2008). In fact 20% of patients will incur weight regain or insufficient weight loss. This subset of patients will gain back on average 22 kg of weight and after 36 months require revisional surgery (Sheppard et al. 2013).

2.4.2 Management Type

Management of this group of patients is complex, and considerable variance of opinion exists as to best practice. Schools of thought range from a highly mechanistic management strategy through to a solely nonsurgical approach. Mechanical/technical problems may be anastomotic/stomal pouch dilatation, fistulae, ulceration, reflux and dysphagia, or lack of restriction. Multiple solutions for these have been advocated. However, given that a multidisciplinary team is beneficial in the success of primary bariatric surgery, some proponents feel it also plays a role in the success of these revisional procedures.

It has been argued that only in a multidisciplinary environment can many of these complex issues be effectively addressed. For example, failure to address important lifestyle, behavioral and psychosocial issues, almost guarantees continued or repeat failure (de Gara and Karmali 2014). In addition, long-term dietary follow-up, outside a specialty clinic, can be costly in either a public or private healthcare system, and may be a contributing factor, to those unable to afford or have these services insured. A unifying factor that draws these issues together is appropriate patient selection. The need for appropriate follow-up, with the multidisciplinary team, is critical to ensure that patients are equipped with the tools, necessary to cope and control their weight when stresses, dietary needs, or socio-economic situations arise. Many bariatric surgeons tend to focus solely on procedural approaches; for example, the importance of original bougie size or pouch dimensions, while failing to address the behaviors that led to sleeve or pouch dilatation.
2.4.3 Medical Tourism

A bariatric medical tourist is an individual intentionally seeking bariatric surgery outside of the province or country, and having an unsatisfactory outcome. This has become an important component of revisional surgery, and a factor in the substantial costs, associated with managing complex bariatric revision patients. Many travel to avoid the long wait times common within a public system, or personal costs, should they either have minimal or no insurance within the private healthcare system. Many patients receive negligible education on behavioral modification pre- or postop. In addition, some institutions do not follow the NIH criteria for bariatric surgery, and patients may not be psychosocially or medically optimal to succeed after surgery. Personal choice, both of procedure and institution, is an important factor.

The burgeoning LAGB failure rate has become a dominant patient group in the revision clinic. A variety of procedural failures are seen, from weight regain to band erosion or slip. While some centers (Ardestani et al. 2011) advocate for repeat laparoscopic band readjustments, so as to avoid removal, most centers find that explantation, and subsequent conversion to a definitive restrictive and/or malabsorptive procedure, is preferred (Deylgat et al. 2012). These endeavors are costly to the healthcare system.

Laparoscopic sleeve gastrectomy patients form the next important group of patients, who may require revisional surgery. Most of these are related to acute complications. Emergent complications such as leakage, bleeding, and thromboembolic episodes can represent a huge range of costly bariatric failure (Sheppard et al. 2014a, b). Later consequences of primary surgery failure, such as weight recidivism, may present demands both for the multidisciplinary team and for formal revisional surgery.

On average the revisional surgery, and care necessary to treat weight regain and complications, is 74 times more expensive than treatment of complications performed in the appropriate healthcare system ($450 vs. $37,000) (Sheppard et al. 2014a, b). It can be expected that as the number of obese individuals increase, so will the number of bariatric medical tourists, along with other inadequately selected or followed bariatric candidates, and thus the number of patients with weight recidivism.

2.5 Management Options

There are several options for revising patients due to weight regain. The proportion of these revisional procedures within a Canadian clinic is outlined in Fig. 2.1.
### Canadian Bariatric Revision clinic characteristics of failed primary bariatric surgery and revision surgery rates

**Fig. 2.1** Illustrations of bariatric procedures provided by the Centre for the Advancement of Minimally Invasive Surgery. Figure created by Maxwell Hurd, University of Alberta.

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<tr>
<th>Initial Procedure Presenting to Revision Clinic</th>
<th>Cause of Procedure Failure</th>
<th>Type of Management</th>
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<tr>
<td>25% - Adjustable Gastric Band (AGB)</td>
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<td>50% - Vertical Banded Gastroplasty (VBG)</td>
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<td>9% - Sleeve Gastrectomy (SG)</td>
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<td>5% - Roux en Y Gastric Bypass (RYGB)</td>
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<tr>
<td>1% - Biliopancreatic Diversion with Duodenal Switch (BPD-DS)</td>
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<th>Weight Regain</th>
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2.5.1 Revision Surgery

RYGB surgery achieves its maximal weight loss at approximately 1 year (Whitlock et al. 2013). The majority of patients then enter a maintenance phase where their weight is relatively stable. However, an average of 21% of patients begin to regain weight at this point (Sheppard et al. 2013). The RYGB can be modified to a distal gastric bypass with revision surgery. This involves lengthening the Roux limb and effectively bypassing more small intestine. Rawlings et al. published retrospective evidence that this revision surgery is able to achieve improved weight loss (Rawlings et al. 2011). Unfortunately, there is still a paucity of evidence supporting the effectiveness of this revision strategy. For RYGB patients, converting to a duodenal switch procedure has been advocated. This is a technically challenging endeavor (Keshishian et al. 2004).

LAGB is unlike other bariatric operations, in that it does not alter the native anatomy of the gastrointestinal system. Consequently, there are multiple revision options available. LAGB can be converted to a LSG, RYGB, or a duodenal switch. Essentially the band is removed, and the subsequent operation is identical to a primary bariatric surgery. LSG has been shown to achieve significant weight loss in patients with a prior LAGB (Berende et al. 2012). However, there were 8.6% staple-line leaks and bleeds with the LSG. This resulted in increased costs, due to reinvestigation and reoperation. This emphasizes the importance of complication rates, when considering the economic impact of a revision surgery.

Revisional surgery is inevitably more costly and complication prone than primary procedures. A recent systematic review summarized the studies of LAGB, revised to either RYGB or LSG (Coblijn et al. 2013). LSG was found to have a 5.6% leak rate after conversion from LAGB. RYGB had a leak rate of 0.9%. This would imply that converting LAGB to LSG is overall more costly. However, there was a wide variation in overall complication rates, for conversion to RYGB among the studies; ranging from 3.0 to 29.3%. Ranges of this order of magnitude make it difficult for interpretation.

There is some evidence for converting LAGB to a duodenal switch procedure. A retrospective study by Topart et al. reported on 21 patients who underwent duodenal switch after LAGB surgery. However, the duodenal switch resulted in significantly more staple line leaks and bleeds, relative to the RYGB (Topart et al. 2007). Consequently, to save on the costs of reinvestigations and reoperations, LAGB is not commonly converted to the duodenal switch.

Revision surgery for a primary LSG involves conversion to either RYGB or BPD/DS. In fact LSG was originally used in a staged approach, to the RYGB and the BPD/DS, in complicated patients (Brethauer et al. 2009). LSG is now commonly done as a stand-alone bariatric procedure. There is evidence that revision to a RYGB is as effective and safe as a primary RYGB surgery (Morales et al. 2010). However, the LSG patients will incur costs needed to undergo the RYGB or the BPD/DS.
Re-sleeve, or performing a second LSG, has been described in the literature. The idea of this revision procedure is to further decrease the size of the stomach. An initial case study described this surgical approach in 2003, when a patient with a BPD/DS underwent an additional LSG (Gagner and Rogula 2003). More recently, a feasibility study reported no complications, with the re-sleeve operation for 13 patients (Iannelli et al. 2011). Unfortunately there is limited evidence for the re-sleeve procedure. Yet the possibility of a surgical procedure with less complications would result in a more cost-effective approach to revising LSG patients.

Vertical banded gastroplasty (VBG) is not commonly performed, but patients who had this procedure are now presenting for revision surgery. In fact, a recent study reports the revision rate to be 21 % (Marsk et al. 2009). VBG can be converted into a RYGB (Gonzalez et al. 2005). There is some evidence that conversion to a RYGB is a better option than simply revising the VBG (Marsk et al. 2009). Unfortunately, there were 4.8 % leaks and 1.9 % bleeds, within the first month after revision RYGB (Gagne et al. 2011). This would make RYGB a less favorable option, if the alternatives were not significantly more costly. In contrast, revision of VBG to LSG has resulted in leak rates as high as 14 % (Berende et al. 2012). Additionally, revision of VBG to BPD/DS has reported leak rates of 22 % (Greenbaum et al. 2011). There is suggestion that VBG conversion to either LSG or BPD/DS can be performed safely and will achieve further weight loss (Jain-Spangler et al. 2013). However, the evidence is primarily based on case series, and revision to RYGB is the more accepted approach.

The cost-effectiveness of revision surgery has yet to be determined. While certain economic studies have included revisional surgery for complications (Klarenbach et al. 2010), no long-term studies to date have assessed the impact of revisional surgery on the healthcare system.

### 2.5.2 Endoscopic Revision

Novel and innovative endoscopic strategies are advocated for primary bariatric surgery failures (Schweitzer 2004). However, the costs of these interventions have not been well documented. Endoscopic revision of RYGB procedure is becoming more established. An endoscopic transoral reduction method was recently investigated in the literature (Thompson et al. 2013). The participants had undergone RYGB surgery and were deemed to have inadequate weight loss. It is known that a larger percentage of patients with weight regain have dilated gastrojejunal junction diameter (Heneghan et al. 2012). The endoscopic approach used a suturing system to decrease the diameter of the GJ junction to 5–8 mm (Thompson et al. 2013). Experimental subjects lost a statistically significant average of 3.5 % of their preoperative weight, compared to 0.4 % in the sham-treated controls. Importantly, none of the 50 experimental patients were reported to have serious adverse events that would require future workup and gastrointestinal intervention. This is one
argument for the endoscopic approach: less risk of adverse events, because of the less invasive method.

The incisionless operating platform™ (IOP) is designed to place placating sutures, within the gastric pouch. A “TransPort” device, with four channels, allows stability of the endoscopic instruments. A full-thickness fold is created and fastened with anchors connected with a suture. The overall goal of the IOP is to reduce the size of the stoma and pouch, after they are found to be dilated. This anchor system was used in a larger prospective trial, with encouraging results in the revision of 116 RYGB patients (Horgan et al. 2010). There were no significant complications associated with the procedure, and the authors reported an 18 % excess weight loss at 6 months post-IOP. Additionally, the authors provided endoscopic evidence of the anchor durability at 12 months post-procedure. Consequently, this endoscopic revision method may have better long-term weight loss.

Another device called StomaphyX™ is designed for the revision of the gastric pouch after failure of RYGB. During endoscopy the device uses polypropylene H-fasteners to create a gastric fold. After repeated folds are created in a circumferential pattern, the pouch size is reduced. A recent retrospective review by Goyal et al., reported on 53 patients who were undergoing StomaphyX™ after RYGB surgery (Goyal et al. 2013). There were no reported complications, and at 2–4 years the excess body weight loss was 4.3 %. The StomaphyX™ has also been used for revision of VBG patients. A retrospective study of 14 VBG patients undergoing revision found an average BMI decrease of 3.6 kg/m² 1 year post-StomaphyX™ (Manouchehri et al. 2011). There were no major complications with the procedure. Based on the limited evidence available, StomaphyX™ appeared to be a safe revision procedure with reasonable short-term weight loss. However, recent evidence suggests that StomaphyX™ may have poor weight loss outcome and increased morbidity compared to other available options (Eid et al. 2014).

Another method is called the over the scope clip (OTSC)™ (Ovesco, Tubingen, Germany). This method uses a Nitinol clip that is applied by an endoscope, in order to reduce the diameter of the gastrojejunal outlet. The idea is that this operation is best performed in patients with diluted GJ junctions, as identified by gastroscopy. In a recent study, 94 patients who initially had a transected vertical gastric bypass presented for treatment with the OTSC endoscopic method (Heylen et al. 2011). After OTSC, 2.1 % of the patients had persistent dysphagia, but there were no major complications. At 12 months post-OTSC, the average BMI had dropped 5.4 kg/m².

Sclerotherapy has also been described in the treatment of weight recidivism in RYGB patients. This method involves injecting a sclerosant into the dilated gastrojejunal stomal tissue. The sclerosant elicits an inflammatory response and edema, which restricts the stomal diameter (Abu Dayyeh et al. 2012). A recent retrospective study reported 231 patients who underwent sclerotherapy after RYGB. They reported that 76 % of their cohort stabilized their weight. They also reported an average of 4.4 % of total body weight loss. However, many of their patients required more than one sclerotherapy session. As well, complications included 1 % ulceration and 2.4 % bleeds, with 1.4 % requiring endoscopic clips.
A paucity of data exists on the costs of these procedures. Dakin et al. are the first to describe the costs of endoscopic revision. IOP and Stomaphyx are said to cost equivalent to an adjustable gastric band ($18,000 USD 2012), an OTSC clip to an endoscopic retrograde cholangiopancreatography ($2,600 USD 2012), and sclerotherapy to a colonoscopy ($1,200 USD 2012) (Dakin et al. 2013). However, no literature exists on the short- or long-term cost-effectiveness of these endoscopic procedures.

2.5.3 Medical Management

For bariatric surgery to be truly effective, long-term medical, dietary, and psychosocial interventions are necessary. Weight regain after bariatric surgery is equally multifaceted (Sheppard et al. 2013).

Adherence to postoperative follow-up is important for weight outcomes in bariatric surgery patients. Weight regain is more prevalent for patients who do not receive postoperative nutritional follow-up (Magro et al. 2008; Warde-Kamar et al. 2004). At these visits, proper eating behavior and practice of physical exercise are evaluated and reinforced (Bond et al. 2004). However, failure of diet and exercise programs is well known, and the costs are almost impossible to assess.

Pharmacologic options are available for weight loss and potentially for weight regain. The medications available have been shown to achieve modest weight loss, in comparison to bariatric surgery (Yanovski and Yanovski 2014). One of the most studied is Orlistat, which is designed to inhibit lipase and prevent the absorption of fats from a meal (Heck et al. 2000). A recent meta-analysis reported that Orlistat achieves 5–10 kg of weight loss, when combined with behavioral intervention (Leblanc et al. 2011). Importantly, the weight loss was maintained for up to 24 months.

Another commonly used agent is Lorcaserin. This medication is designed as a selective agonist of the serotonin 2C receptor (Smith et al. 2009). The idea is that it reduces appetite, which subsequently reduces weight. The efficacy of Lorcaserin is similar to Orlistat, in terms of weight loss. A large randomized trial of 3,182 obese patients compared Lorcaserin to placebo (Smith et al. 2010). After 1 year, half of the Lorcaserin-treated patients achieved 5 % weight loss or more.

Solely a medical management program is not a cost-effective method for long-term weight loss. No significant difference exists in the QALY, between primary care physician follow-up and lifestyle behavior modification programs. Short-term ICER is $115,397 USD per QALY, compared to a willing-to-pay cost of $50,000 USD per QALY. Lifestyle counseling programs were only cost-effective, if the payee were to invest $400 USD per kg-year, for a loss of 10.87 kg-year (Tsai et al. 2013). Furthermore, the cost of Orlistat is €66 or $138 USD per month, resulting in an ICER of €17,000 per QALY (Lacey et al. 2005). Both Orlistat and Locaserin are not cost-effective therapies for weight loss, and only 10 % of simulations were cost-effective at $100,000 USD per QALY. To date, targeted
medical interventions have not been successful and far outweigh the cost of primary bariatric surgery.

Limited data is available on the cost analysis of these revisional options for weight regain. Data exists in reviews and only as cost ranges. These novel technologies and therapies tend to fail, are temporary fixes, have a large “halo effect,” and adhere to the sin wave of technology. The ultimate goal of revisional procedures is to decrease the comorbidities of patients, and long-term data is needed in order to determine their efficacy.

2.6 Costs Associated with Obesity Recurrence

While information increases on weight regain in long-term studies around the world, very little research has been done to look at the revision rates, within the postoperative bariatric population, due to either weight regain or comorbidity recurrence. It would be safe to say that not only do these patients begin to accumulate costs in surgical needs but also in recurrent pharmaceutical costs, to manage their comorbidities. Characterizing the costs and cost-effectiveness of revisional surgery will be a necessary component to analyzing the overall benefit of bariatric surgery, for patients and the healthcare system.

2.6.1 Revisional Surgery Costs: Public Healthcare Versus Private

Bariatric revision surgery is a growing enterprise and is a major healthcare cost, so much so that weight loss programs have begun to implement revisional surgery into their practice, throughout Canada and the USA. In Canada, these costs are significant enough to our healthcare system, that separate clinics from the primary surgical clinics are being funded. These clinics specialize in revising bariatric procedures and reconnecting patients with a multidisciplinary team. The understanding of these clinics is as stated in the literature, that postop primary bariatric surgery is successful with a team approach and lifestyle modification, and it should also be so after revisional surgery, not just a technical surgical issue.

These clinics are funded through the healthcare system and generally comprise approximately 50 revisional procedures each year per institution. The provincial government funds all of these costs for patient care. Depending on the province, certain revisional procedures are covered (LAGB only covered in Alberta, Québec, and Newfoundland and Labrador, whereas the Maritimes only cover LSG). While other provinces do not have the facilities, surgical expertise, or resources to perform revision bariatric surgery, patients are referred, and their original province is billed.
Revisional costs are billed similarly to a primary bariatric procedure, and each procedural cost is tabulated as shown in Table 2.2. These costs were based on the single payor healthcare provider, in the province of Alberta, Canada. The majority of expenditures are from VBG revision, comprising 85% of surgeries. However, depending on which Canadian province, costs may vary. In major bariatric centers in provinces, such as British Columbia and Ontario, surgical billing for these bariatric procedures varies from $1,100 CAD to $1,400 CAD, respectively. Additional billing modifiers for patient BMI exist, in some provinces equivalent to an increase in 25% (Ministry of Health and Long Term Care 2014).

Other public healthcare systems globally also have bariatric surgery coverage, through their national healthcare system, such as most European countries and Australia. Several institutions in these countries have commented on the cost-effectiveness of primary bariatric surgery, including revision rates, however not the specific cost of a revisional procedure.

The complexity of the US multipayer system and the variability of insurer coverage, with its case-by-case approach for specific bariatric surgical, endoscopic, and non-procedural interventions across different states, make cost calculations a challenge. However, notably in the literature, primary bariatric surgery is substantially more expensive in the USA than Canada for gastric bypass ($24,000 USD vs. $18,000 CAD), respectively (Mehrotra et al. 2005). One article determined the difference in costs between primary and revisional gastric band conversion to gastric bypass in the USA. It demonstrated that revisional surgery was $13,000 USD more expensive, at approximately $50,000 USD (Worni et al. 2013). No other published literature exists to date, quantifying the cost of revisional surgery in the USA.

While the cost-effectiveness of revisional surgery due to weight regain has yet to be calculated, the cost-effectiveness of weight regain 5 years after primary bariatric surgery was ascertained for LRYGB and LAGB. The ICER was $24,100 USD and $26,700 USD for LRYGB and LAGB relative to no surgery, respectively. The willingness to pay for most bariatric procedures is $50,000 USD per QALY,

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Surgeon billing ($)</th>
<th>Anesthesiologist billing ($)</th>
<th>OR costs ($)</th>
<th>Hospital stay ($)</th>
<th>Total ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAGB removal</td>
<td>900</td>
<td>400</td>
<td>1,100</td>
<td>1,500</td>
<td>3,900</td>
</tr>
<tr>
<td>LAGB removal and revision</td>
<td>2,500</td>
<td>1,400</td>
<td>8,900</td>
<td>10,500</td>
<td>23,300</td>
</tr>
<tr>
<td>Revision LRYGB/ LSG</td>
<td>2,900</td>
<td>1,100</td>
<td>5,600</td>
<td>9,000</td>
<td>18,600</td>
</tr>
<tr>
<td>VBG revision</td>
<td>2,700</td>
<td>1,100</td>
<td>5,600</td>
<td>9,000</td>
<td>18,400</td>
</tr>
<tr>
<td>Reversal of BPD-DS</td>
<td>2,900</td>
<td>1,100</td>
<td>5,600</td>
<td>9,000</td>
<td>18,600</td>
</tr>
</tbody>
</table>

Abbreviations: CAD Canadian dollars, OR Operation room, LAGB Laparoscopic adjustable gastric band, LRYGB Laparoscopic Roux-en-Y gastric bypass, LSG Laparoscopic sleeve gastrectomy, VBG Vertical banded gastroplasty, BPD-DS Biliopancreatic diversion–Duodenal switch
making bariatric surgery with weight regain still cost-effective but not ideal for patient health. However, with the increasing number of LAGB removals and revisions, the cost analysis could be adversely affected (Wang et al. 2014).

2.7 Complication Rates and Costs of Revision Surgery

The average cost of an operative revisional procedure is $5,600 CAD in Alberta, Canada. The complication rate of revision surgery ranges from 5.5 to 19.4 % (Worni et al. 2013; Ardestani et al. 2011; Biertho et al. 2005; Mognol et al. 2005; Nguyen et al. 2012; Tucker et al. 2008; Yazbek et al. 2013; Hedberg et al. 2012). Because of the complexity of revision surgery, complication rates have been noted to increase, some significantly higher than after primary surgery. They are particularly high after biliopancreatic diversion and duodenal switch (21–25 %) (Klarenbach et al. 2010).

Complication costs can vary from $200–$400 for an investigative procedure to $800–$1,000 for a single surgical procedure. The average cost of complications after LSG revision surgery is $1,500 CAD, $9,900 CAD after RYGB, and $1,300 CAD after LRYGB. These costs do not factor in procedures necessary for ventral or incisional hernia. A second revisional surgery has been noted to occur in 20–25 % of revision surgeries, and 13–25 % of secondary revision surgeries are due to obesity recurrence (Jacobs and Fassbender 1998; Finkelstein 2001; Rawlins et al. 2011; Gagner and Rogula 2003). In addition, hospital stay has been noted to be longer than for primary surgery by several days, thereby incurring an additional cost to the system (Worni et al. 2013; Nguyen et al. 2012; Tucker et al. 2008). Each day in hospital has a cost of $1,500 CAD or $3,000 CAD for the intensive care unit (ICU). As noted in the US literature, revisional gastric banding incurs an additional $4,000 USD in hospital stay, compared to primary gastric banding, and $13,250 USD for revisional gastric bypass (Keshishian et al. 2004; Gonzalez et al. 2005).

Other expenses to factor in are the cost of a bariatric intervention team. It involves the cost of consultations with dieticians, psychologists, nurses, and surgeons. Most patients will have four to seven appointments with the team before undergoing surgery, leading to a cost of approximately $500.

2.8 Recurrence of Comorbidities and Associated Costs

Obese individuals are known for incurring twice or more healthcare expenditures than their normal weight counterparts. Several sources have reported the cost savings of bariatric surgery because of comorbidity resolution. Pharmaceutical costs are a major component of these total expenses. Diabetes is a costly comorbidity, ranging from $1,250 to $5,000 CAD in ongoing pharmaceutical costs, as well as €2,950 EU and £1,550–£4,500 GBP in annual costs (Karim et al. 2013;
Klarenbach et al. 2010; Lacey et al. 2005; Clegg et al. 2003). Other large expenses include the cost of continuous positive airway pressure (CPAP), hypertension, and hyperlipidemia treatment, along with knee replacements. These have been reported to be yearly costs of $280, $800, and $500 CAD, respectively, with knee implants in a much higher range. Hypertension has also been quoted to cost £2,000 GBP annually (Karim et al. 2013).

Obese nonoperated individuals already have significantly higher pharmaceutical expenditures than normal weight individuals (£400 vs. £15 men, £210 vs. £75 women). Additional costs are increased primary care visits (£130–£175) and hospitalization (£1,200–£1,300). However, these costs are noted to increase within the first year of surgery and reduce slightly over time. Each increase in one BMI point denotes an increase of £15 per person per year in healthcare expenditures (Tigbe et al. 2013).

Primary bariatric surgery reduces comorbidities by 40–70 %, depending on the procedure (Peterli et al. 2013; Leyba et al. 2011). Resolution and improvements in comorbidities have been implicated in annual cost savings of pharmaceuticals of $2,200 USD per patient, after gastric bypass (Monk et al. 2004). Other countries have reported reductions of 40 % in pharmaceutical costs and a total cost savings of £30,400 GBP per year (Karim et al. 2013).

Several publications have described revisional surgery as being necessary for comorbidity resolution after weight regain. The percentage of comorbidities in revision patients ranges from 13 to 42 %, similar to rates in the primary bariatric population. One study reported that comorbidity recurrence was the primary cause of revision surgery, in 22 % of patients. A single study by Weiner et al. 2013, in the United States healthcare system demonstrated that by the fourth postop year, costs of inpatient stay, physician and outpatient visits, and pharmacy costs began to increase. No literature so far has commented on weight recurrence, in the period from band removal to revisional surgery, or the costs of weight regain during this time.

Studies reporting on follow-up of longer than 5 years have noted that weight regain has been a factor in comorbidity return. One study determined that after a period of 10 years, weight regain created an increase in all collected comorbidities, including diabetes (1–7 %), hypertension (24–41 %), and hyperlipidemia (27–30 %) (Sjöström et al. 2004). However, another long-term Swedish study noted that there was a cost savings over a 7–20 years period of $230, between the control and bariatric surgery population for comorbidities. The weight loss of the long-term data was found to be 17–18 % at 10–20 years following primary surgery (Neovius et al. 2012).

Figure 2.2 depicts an overall summary of costs, from primary bariatric surgery to revisional bariatric surgery.
2.9 Summary

Obesity consumes a large amount of health resources to manage associated medical, mental health, and social issues. Billions of dollars are spent and invested in this complex chronic disease. Bariatric surgery is the only evidence-based resource for sustainable weight loss. However, weight regain has been noted in 10–20% of patients after 36 months. Along with weight recidivism, comorbidities can also recur, costing more in clinical and pharmaceutical care. Whether more effective patient selection, and multidisciplinary revisional interventions (surgery, endoscopic treatment, and medical management), could result in cost savings has yet
to be determined. However, all contribute to the global costs of bariatric surgical failure. These cannot be overlooked, in an accurate economic analysis. These costs may range from $15,000 CAD to $24,000 USD per patient, totaling millions in revision expenditures in North America. It is essential to include them in the overall cost-effectiveness assessment of bariatric surgery.

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