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Cost-Utility Analyses of Interventions to Prevent and Treat Obesity in Israel

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in collaboration with
Elliot Rosenberg and Bruce Rosen

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EXECUTIVE SUMMARY

Obesity is a serious risk factor for many chronic diseases. It is also quite an expensive one, generating direct health service costs of approximately NIS 1.14 billion, which is equivalent to 0.16% of Israel's Gross Domestic Product – or 2% of the country's health expenditure.

The objective of the study was to assist Israeli policymakers in their efforts to prioritize interventions to prevent and treat obesity in Israel by calculating cost-effectiveness ratios of relevant interventional modalities.

Cost-utility ratios of three interventional modalities for the prevention and treatment of obesity – dietary counseling, pharmaceutical interventions and bariatric surgery – were calculated by building a model using primary Israeli data for dietary counseling interventions, as well as by adapting data from the published literature to epidemiological and economic parameters characterizing Israel for all three interventional modalities. Public health interventions such as those delivered at schools, worksites and other community settings were not covered as the literature does not provide sufficient information to calculate generalizable cost-utility analyses.

Generally, the ratios were found to be very favorable: the majority were either cost-saving or very cost-effective. Cost-saving interventions are those that actually reduce costs overall, as the treatment costs averted by the decrease in morbidity exceed the cost of the intervention. Very cost-effective interventions are those that achieve an increase in quality-adjusted life years (QALYs) at a relatively low cost (the cost per QALY is less than the per capita GNP, in keeping with the accepted WHO criteria).

Dietary counseling was either cost-saving or very cost-effective, while pharmaceutical interventions were either very cost-effective or cost-effective. The various surgical interventions ranged from being cost-saving to cost-effective, contingent upon the specific technique and the study. Generally speaking, these three modalities incrementally address populations that are increasingly more obese or difficult to treat. As such, they essentially do not compete with one another. Differences in cost-effectiveness exist within each treatment modality, but the data are not robust enough to facilitate within-modality prioritization at this point.

This report confirms the cost-effectiveness of several interventions already funded to some degree within the basket of health services but also suggests the appropriateness of funding heretofore unfunded interventions. While funding exists for dietary counseling for the obese or the severely overweight with additional risk factors and for surgical interventions for those with Class III obesity or with Class II obesity and additional risk factors, pharmaceutical interventions such as sibutramine and orlistat are not currently funded. They have been shown to be very cost-effective in this report, hence they too should be considered for funding, contingent upon a review of their effectiveness/safety profile.

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1. INTRODUCTION

Cost-utility analysis (CUA) combines the disciplines of epidemiology, medicine and economics in order to rank projects according to the cost per quality-adjusted life year (QALY) saved. CUA is now used by many countries throughout the world as a necessary (albeit insufficient) tool in deciding health service priorities. Other factors such as equity and political pressure may also need to be taken into account.

In addition, the use of CUA enables preventive and curative projects to compete for the limited societal resources on one level playing field, thus overcoming the universal phenomenon that health systems are dominated by persons working in curative as opposed to preventive medicine.

In 2005, the Ministry of Health established the Healthy Israel 2020 initiative. Since then, some 300 professionals have been appointed to 20 different committees. Three subcommittees of the Health Behaviors Committee focused on obesity control, smoking control and enhancement of physical activity, respectively, and they have recommended several interventions in each area. There is now a need to prioritize these interventions both within and between these areas of activity. CUA is the gold-standard objective tool with which to carry out such prioritizations.

This report is one of a trilogy that will provide estimates of the CUA of various interventions to prevent and treat obesity, to reduce the smoking-related burden of disease and to enhance physical activity. The results of this study will enable standardized comparisons (as described in the Methods section, below) to be made between interventions to prevent and reduce the prevalence of obesity and preventive and curative interventions for other diseases. This process should encourage more rational decision-making.

2. KEY EPIDEMIOLOGIC DATA CONCERNING OBESITY

The increasing prevalence of obesity is an important public health problem that contributes to excess morbidity and, to a lesser degree, to increased mortality (WHO, 2000). The World Health Organization (WHO) estimates the total cost of obesity to be between 7% and 25% of total health care costs worldwide (WHO, 2000). This is in contradistinction to overweight (i.e., BMI ranging from 25.0–29.9), which, at least for those aged 65 and older, may even confer a mortality benefit (Janssen, 2007).

It is clear, though, that obesity leads to increased morbidity. It has been shown to increase the relative risk of many diseases, in particular, type 2 diabetes mellitus, hypertension, pulmonary embolism and endometrial cancer (Birmingham et al., 1999) (Table 1).

Table 1: Relative Risks (RR) and Population Attributable Fractions (PAF) of Obesity for Intermediate Risk Factors and Chronic Diseases in Israel

	RR	PAF
Hyperlipidemia	1.41	11.2%
Hypertension	2.51	31.6%
Breast cancer	1.31	9.1%
Coronary artery disease	1.72	17.9%
Colorectal cancer	1.16	4.7%
Endometrial cancer	2.19	26.6%
Gallbladder disease	1.85	20.6%
Pulmonary embolism	2.39	29.8%
Stroke	1.14	4.0%
Type 2 diabetes	4.37	50.7%

Notes: The population attributable fraction (PAF) is the reduction in incidence that would be observed if the population were entirely unexposed (i.e., no one was overweight), compared with its current (actual) exposure pattern (Rothman, 1998). PAF can be thought of as the percentage of the disease burden (incidence) that is due to the risk factor of being overweight.

Its formula is

$$PAF = \frac{Px\ (RR-1)}{Px\ (RR-1)+1}$$

where Px is the proportion of exposure in the population and RR is the relative risk ratio associated with that risk factor.

The sum of the PAFs may exceed 100%, because each death is recorded only under a particular main cause of death e.g., diabetes or hypertension, despite the existence of co-morbidities secondary to obesity. Thus, we see that 59.1% of diabetes mortality and 33.7% of hypertension mortality are attributable to being overweight.

Calculating the Monetary Burden of Disease

Disease-specific data on relative risks from a Canadian study in 1997 (Birmingham et al., 1999) were adjusted to Israeli conditions by taking into account the Israeli population in 2008 and the relative obesity rates in the populations over age 20 (i.e., 21 and above) (Birmingham et al., 1999; Central Bureau of Statistics, 2006). The right-hand column in Table 1 shows the population attributable fraction (PAF) of disease attributable to obesity in Israel. Disease cost data were adjusted by the Canadian consumer price index to 2008 price levels and by the appropriate exchange rate (for drugs and treatments). These data were then adjusted by the relative expenditures (OECD, 2009; CBS, 2007; Historic exchange rates; Statistics Canada) on health services per capita in Israel ($1,608 per capita in 2008) and in Canada (Can$1,874 per capita in 1997) and the relative size of the obese populations aged 20 and over (in 2008, Israel's obese population aged 20 and over was 22.2% of that in Canada in 1997). The resultant cost was multiplied by the PAF to provide an estimate of direct health service costs attributable to obesity in Israel (central column in Table 2).

Table 2: Estimated Direct Health Costs of Obesity in Selected Co-Morbidities: New Israeli Shekels (2008)

	Total Cost	Cost Attributable to Obesity	Percent of Total Cost Attributable to Obesity
Breast cancer	131,620,043	11,977,424	1.1
Coronary artery disease	1,166,349,158	208,776,499	18.3
Colorectal cancer	250,162,681	11,757,646	1.0
Endometrial cancer	29,270,857	7,786,048	0.7
Gallbladder disease	404,843,369	83,397,734	7.3
Hyperlipidemia	377,794,630	42,312,999	3.7
Hypertension	1,350,793,663	426,850,797	37.4
Pulmonary embolism	74,226,127	22,119,386	1.9
Stroke	1,702,753,681	68,110,147	6.0
Type 2 diabetes	507,117,901	257,108,776	22.5
Total	5,994,932,109	1,140,197,456	100.0

From the above it is clear that three diseases – hypertension, diabetes and coronary artery disease – account for 78.2% of the total direct health costs of obesity. It can be seen that the total direct health costs attributable to obesity in Israel amount to roughly NIS 1.14 billion, which is equal to about 0.16% of the GDP, and approximately 2% of Israel's health expenditure. This is equivalent to an average annual expenditure of NIS 1,663 on each of the estimated 685,772 obese Israelis aged 20 and over.

Using the most recent (2003–2004) national obesity survey data, obesity is currently estimated to be present in 685,772 Israeli adults (i.e., 14.8% [Israel Center for Disease Control, 2003–2004] of the 2008 total adult population aged 20+ of 4,633,593 persons). Even modest weight losses by this sizeable group can meaningfully contribute to reductions in risk factors for disease. There are indications that intentional weight loss can also reduce the risk of diabetes mellitus (Aucott, 2008). A weight loss of 10 kg has been associated with a fall in total cholesterol of 0.25 mmol/l (9.7 mg/dl), and a fall in diastolic blood pressure of 3.6 mmHg. A weight loss of 10% is associated with a fall in systolic blood pressure of 6.1 mmHg (Avenell et al., 2004). Controversy exists though, regarding the potential for intentional weight loss to confer a mortality benefit (Nilsson, 2008; Sorensen et al., 2005; Williamson, 1999; Williamson, 1995). On the other hand, there is evidence to support the mortality-reducing benefits of bariatric surgery (Sjöström et al., 2007). In light of this evidence, and taking into consideration the inherent logic of dietary counseling and pharmacotherapy conferring similar health benefits, it was assumed that all three modalities conferred both mortality and morbidity savings.

Two broad strategies are employed to achieve weight loss: public health measures and clinical measures. The former include, among others, subsidizing healthy food, reducing portion sizes in fast-food establishments, improving nutritional labeling, reducing television advertisements for unhealthy food, and banning the sale of sugared drinks and other unhealthy food in schools.

Unfortunately, there is a dearth of data on the percentage of obesity attributable to these factors, on the effectiveness (in terms of obesity cases prevented) of primary preventive government, industry, and community-oriented initiatives implemented to address these issues, and there is, therefore, a lack of available high quality cost-utility analyses in the scientific literature.

Consequently, the main focus of this report – the first comprehensive review of CUA for interventions to reduce obesity to be carried out in Israel – will be on clinical preventive and therapeutic interventions for the obese carried out in the health care environment. Public health interventions such as those delivered at schools, worksites and other community settings were not covered as the literature does not provide sufficient information to calculate generalizable cost-utility analyses.

3. Objectives

The objective of the study was to assist Israeli policymakers in their efforts to prioritize interventions to prevent and treat obesity in Israel by calculating cost-effectiveness ratios of relevant interventional modalities.

4. Methods

Based on the current state of the art, the following major areas of intervention to prevent or reduce obesity were identified:

- Dietary interventions
- Pharmaceutical interventions
- Surgical interventions.

Dietary, pharmaceutical and surgical interventions are actually generally appropriate for different subgroups of the obese population, although they still vie for the same limited health service resources. Therefore, CUA-driven prioritization will be conducted between different specific modalities *within* each broad interventional category. The data should also provide us with the means to examine whether the addition of a new pharmaceutical intervention (beyond those already being provided) should be preferred to the addition of a new surgical intervention.

A literature search was carried out using the MEDLINE database for the keywords (cost-containment, cost-benefit, cost-effectiveness, cost-utility) AND (obesity).

Due to resource (i.e., time) and data-availability constraints, it was not deemed feasible to calculate CUA for each intervention type based on primary Israeli data. Consequently, data from the world literature was used in an adjusted form. However, this was feasible in the case of dietary interventions.

Costs

Data on employment costs of health service staff were provided by the Budgeting Department of the Ministry of Health. Pharmaceutical costs were obtained from the Pharmaceutical Department of the Ministry of Health. Building costs were based on $1,500 per square meter amortized over 40 years at 3%. Building maintenance costs, including heating and utilities, amounted annually to 8% of building costs.

Costs included are those direct costs viewed from a "narrow" health-services perspective, as data on costs falling outside the health system, such as work absences, transport costs to receive treatment, and out-of-pocket expenses are not readily available for Israel. Therefore our estimates as to the cost-utility of interventions can be viewed as conservative in nature, since the inclusion of savings in work absences and transport costs would have served to reduce the costs per QALY of the interventions.

Costs of treating cardiovascular diseases were obtained from a recently published study of a national program to prevent hypertension carried out in Israel (Yosefy, 2007). Costs of treating cerebrovascular disease were obtained from a recent CUA of providing specialist treatment wards for stroke victims in Israel (Ginsberg, 2007).

All costs are presented at 2008 price levels, based on an exchange rate of NIS 3.60 to the US dollar and an inflation rate of 3.25% in that year.

Costs for the treatment of cases of non-fatal acute myocardial infarction (AMI), unstable angina pectoris (UAP) and peripheral vascular disease (PVD) came to NIS 36,442, NIS 31,142 and NIS 37,125, respectively. Costs of each stroke case came to NIS 114,692. The latter included subsequent rehabilitation and therapy in a home setting (Ginsberg, 2007). Treatment costs of NIS 11,180 and NIS 9,417 were imputed for treating AMI and UAP fatalities, respectively (Yosefy, 2007). Other obesity-associated causes of mortality were assumed to have associated treatment costs similar to AMIs.

Quality-Adjusted Life Years (QALY)

Quality-Adjusted Life-Years, or QALYS, are a measure of disease burden, incorporating both the quality and the quantity of life lived. Thus, morbidity, mortality and functionality are represented. The QALY is typically used to ascertain health benefits that accrue from health interventions. As this study explores the health-economic impact of weight-loss strategies, the health burden of overweight and obesity in terms of QALYs will first be elaborated upon.

It is well accepted that weight status impacts the quality of life as measured by QALYs. Table 3 shows the classification of weight according to the BMI (Body Mass Index = weight in kg/[height in meters]^2) together with the average QALY weight associated with that BMI level (Sach et al., 2007). These results are based on patients aged 45 or over in one UK general practice, who completed various standard questionnaires as to their health and functionality and provided information on their characteristics and co-morbidity. BMI was categorized according to the WHO recommendations. Regression analysis was used to compare the resultant health-related quality of life (HRQL) derived from the health and functionality questionnaires of normal BMI patients to the HRQL of patients in other BMI categories, while controlling for patient characteristics and co-morbidity. The QALY weights range from 0 (dead) to 1.00 (perfectly healthy). No group attains a perfectly healthy score, because the aging process gradually causes increased dysfunction in all persons, whether obese, of desirable weight or underweight. The table clearly shows the inverse relationship between obesity and quality of life.

It should be noted that the QALY weights (shown in Table 3) take into account the direct impact of obesity on functionality, even before a disease is diagnosed. For example, the functionality questionnaire will pick up evidence of "shortness of breath when climbing stairs" in many people who have not yet received a clinical diagnosis of coronary heart disease.

Table 3: QALY Weights by BMI Level

BMI (kg/m^2)	Description	QALY Weight
20 or less	Underweight	0.741
20 to 25	Desirable	0.787
25 to 30	Overweight	0.769
30 to 35	Obese Class I	0.707
35 to 40	Obese Class II	0.672
Over 40	Obese Class III (morbidly/severely obese)	0.624

The art of assigning values to health states or QALY weights is not yet an exact science. Therefore, disability weights (DW, where DW=1-QALY value) for relevant diagnoses were obtained by taking an average of the values reported in the literature (Brady et al., 2007; Lacey and Walters, 2003; Sandercock et al., 2004; Bosch and Hunink, 2000; Fryback et al., 1993). QALY losses due to morbidity were calculated by multiplying the QALY weights by the duration of disability. QALY gains from decreased morbidity from a non-fatal AMI, UAP or PVD were estimated to be 0.425, 0.324 and 0.493 respectively (for both genders), based on a meta-analysis of disability weights in the international scientific literature (Brady et al., 2007; Lacey and Walters, 2003; Sandercock et al., 2004; Bosch and Hunink, 2000; Fryback et al., 1993; ACSIS, 2007; CBS, 2007; Mackay and Menasah, 2004).

A recent Israeli study estimated a 0.225 QALY loss from morbidity resulting from cerebrovascular events (CVAs) (Yosefy, 2007).

However, QALY losses also occur due to mortality. The average age of death for males was 62.0 years for those with a diagnosis of UAP, 62.4 years for those with AMI, 77.1 years for those with CVA and 77.2 years for those with all other causes. For females, respective average ages were 68.3 years for those with UAP, 70.5 years for those with AMI, 80.6 years for those with CVA and 79.9 years for those with all other causes. Case fatality rates were based on Israeli data: 0.7% for UAP (ACSIS, 2007), 5.1% or AMI (ACSIS, 2007) and 13.8% for CVA (Ginsberg, 2007), with the annual risk of dying from all other causes being 0.24%.

The calculation of potential years of life lost (PYLL) per case was based on projections of the age-gender and religion-specific life expectancy (Central Bureau of Statistics [CBS], 2007). Male PYLL amounted to 21.4 years from UAP, 19.8 years from AMI and 11.0 years from all other causes. Female PYLL was 19.8 years from UAP, 16.1 years from AMI and 11.7 years from all other causes.

The clear majority (77.8%) of AMIs occurred in males (ACSIS, 2007). As stated above, QALY gains from averted mortality were based on an average age of death from AMI of 62.4 and 70.5 years in males and females, respectively (CBS, 2007). This resulted in 19.8 and 16.1 life-years saved (representing the gender-specific life expectancy at ages 62.4 and 70.5 years, respectively) for males and females, respectively (CBS, 2007). Using data from the World Health Organization (WHO, 2002), these life-years saved were converted into health-adjusted life expectancies (HALE) in order to take into account the increase in dysfunction due to the aging process. HALE or QALY gains from averting an AMI death were estimated to be 14.7 and 11.1 for males and females, respectively. A similar calculation results in QALY losses of 16.1 and 14.2 for male and female UAP fatalities and QALY losses of 7.9 and 8.1 for male and female deaths from all other causes, respectively. QALY losses of 11.5 per CVA death were estimated by combining WHO and Israeli data (Yosefy et al., 2007; Mackay and Menasah, 2004).

Cost Effectiveness Ratios

The metric used to represent these ratios is the cost per QALY. The basic formula used for calculating the cost per QALY is as follows:

$$\text{Cost per QALY} = \frac{\text{Net cost of intervention}}{\text{QALYs gained}}$$

where:

Net cost of intervention = Costs of (intervention) program less the savings achieved in treatment costs as a result of decreased morbidity due to implementation of the program.

QALYs gained = Gain in QALYs as a result of decreases in incidence and/or mortality due to the intervention.

The following two types of cost-effectiveness ratios are widely reported in the literature:

The average cost-effectiveness ratio (ACER) relates the net costs of the intervention (compared with a do-nothing scenario) to the gain in QALYs due to the intervention. The ACER is used to answer the question whether the intervention is worthwhile per se.

The incremental cost-effectiveness ratio (ICER) relates the incremental net costs of the intervention (compared with an alternative intervention) to the incremental gain in QALYs (compared with an alternative intervention) as a result of the intervention. The ICER provides decision-makers with information regarding the financial cost incurred when implementing an alternative intervention to achieve a known increase in QALYs. ICERs have been presented where available.

Decision Rules/Definitions

By combining data relating to the costs and effectiveness, the cost per QALY was calculated for each intervention. Taking into account the resources available in Israel, an intervention is defined as being cost-saving, very cost-effective or cost-effective as follows:

- Cost-saving: yields actual savings as well as contributing additional QALYs
- Very cost-effective: the cost per QALY is less than the per capita GNP of NIS 97,700 in 2008) (CBS, 2009)
- Cost-effective: the cost per QALY is 1–3 times the per capita GNP (NIS 97,700–NIS 293,100), respectively.

If the cost per QALY is more than three times the GNP per capita (>NIS 293,100) then the intervention is regarded as not being cost-effective (WHO, 2001).

Adapting International Studies

In the cases where CUA results are based on studies in other countries, data on costs per QALY from international studies ideally need to be carefully adapted to Israeli conditions to take into account differences in the following parameters:

- Morbidity levels
- Mortality or case fatality rates
- Labor costs
- Treatment styles
- Gender-specific life expectancies (CBS, 2007; Anderson, 1999)
- Gender-specific HALE (health-adjusted life expectancies)
- Period in which the study was performed.

We assumed there were no significant difference in QALY weights for specific diseases between Israel and other developed countries. We adjusted as many of the above factors as possible, subject to data constraints, in order to convert values from international literature to Israeli equivalents. A final means of adaptation occurred where there was a lack of access to the original epidemiological data sets: in this case, estimates were converted to the Israeli setting solely through adjusting the economic parameters.

Adjusting Economic Parameters

Foreign currency costs were converted to 2008 NIS price levels based on the health or consumer price index of the country concerned (U.S. Department of Labor, 2008). Labor costs (representing non-tradable goods) were converted to NIS at 2008 price levels at the estimated PPP (purchasing power parity) exchange rate of 2.94 per US$, 4.48 per Euro, 5.11 per pound sterling, 0.41 per Danish kroner, and 1.81 per Swiss franc. This takes into account the fact that the prevailing currency exchange rates do not reflect the purchasing power of different countries. It was assumed that 70% of all health-service treatment costs and costs of interventions that contained drug or surgical components would be labor costs. For interventions based purely on counseling, the labor component was assumed to equal 90% of the total costs. For interventions based purely on pharmaceutical costs, the international exchange rate was used, as the drugs are internationally tradable goods.

5. TYPES OF INTERVENTIONS

5.1 Dietary Interventions

Persons who are obese or just overweight should initially try to reduce their weight by dietary interventions. Although all adults should be screened to assess their BMI, clinical interventions such as dietary counseling have been recommended only for the obese, but not for overweight individuals (U.S. Preventive Services Task Force, December 2003).

These should be complemented by counseling and other interventions to increase physical exercise. These will be addressed in a separate report in this series.

A systematic review (Avenell et al., 2004) of randomized, controlled trials lasting a minimum of 52 weeks, reported an association between low-fat diets and weight loss of 5.31 kg (95% CI 4.77 kg to 5.86 kg) after 12 months and 3.55 kg (95% CI 2.55 kg to 4.54 kg) after 36 months.

As noted, conclusive evidence linking non-surgical weight loss with decreases in mortality and possibly even morbidity in obese individuals without additional risk factors for diabetes, hypertension or hyperlipidemia is still unavailable (Afterburn et al., 2004; Hutton and Fergusson, 2004; Drew et al., 2007; Torgerson, 2004). Therefore, intermediate markers of morbidity and mortality endpoints were considered in assessing clinical benefit. Their clinical impact was extrapolated as per their population attributable fraction (PAF) for chronic disease. Leading candidates for intermediate markers were generated from the PAF of obesity for the chronic diseases listed in Table 1. These included fasting blood glucose, hemoglobin A1C or IGT[1] for diabetes (PAF=50.7%), blood pressure for hypertension (PAF=31.6%), and blood lipids for hyperlipidemia (PAF=11.2%). We did not identify intermediate markers for the following health outcomes caused by obesity: pulmonary embolism (PAF=29.8%), endometrial cancer (PAF=26.6%), gall bladder disease (PAF=20.6%). Blood lipid (LDL-C) changes were chosen as the intermediate marker of choice in this study rather than hypertension or markers of prediabetes/diabetes, since a time-intensive model linking this parameter with health morbidity and mortality had already been developed for another study.

A small meta-analysis (Table 4) was carried out in order to calculate the effectiveness of dietary counseling interventions in lowering levels of LDL-C. This resulted in a pooled estimate of a 7.67% decrease in LDL-C.

[1] IGT= Impaired glucose tolerance as shown by the oral glucose tolerance test.

Table 4: Effect of Dietary Counseling on LDL-C Levels

Reference	Patients N	% Change in LDL-C Level
Denke	41	-6.2%
Denke and Grundy	50	-7.8%
Denke and Grundy	26	-9.0%
Wood et al.	40	-10.7%
Keenan et al.	21	-2.8%
Pooled Estimate	178	-7.67%

Each 1% decrease in LDL-C is associated with a reduction of 0.00011% in fatal AMI, 0.00011% in nonfatal AMI, 0.0004% in fatal UAP, 0.0062% in non-fatal UAP, 0.00046% in PVD, 0.00167% in fatal and non-fatal strokes, and 0.00353% in all other causes of morbidity and mortality (Ito et al., 2001).

Total treatment savings were estimated by multiplying the pooled estimate percentage decrease in LDL-C (viz., 7.67%) by the associated marginal decreases in morbidity per unit decrease in LDL-C and then by the diagnosis-specific treatment costs (listed in the Costs section on pages 4–5 of this report).

An intervention model was constructed on the basis of primary Israeli data to estimate the cost per QALY of dietary interventions. Firstly, everyone aged 20 and above (n=4,633,593) would have their waist circumference and BMI measured. The 14.8% (685,772 obese persons) with a BMI $\geq$ 30 would then receive dietary counseling.[2] The annual cost of dietary counseling in Israel totaled NIS 250.4 per person, based on the client making two visits during the first three months (U.S. Preventive Services Task Force, 2003) and monthly visits thereafter (as was deemed practical by local nutritionists). Based on common Israeli practice, it was assumed that 50% of the visits would be to a physician, 25% to a trained nurse, 20% to a dietician and the remaining 5% to a psychologist. A sum of NIS 14.6 was added for room overheads, and a further NIS 34.4 and NIS 0.76 were added to cover the overhead of initial screening and staff training per counseled person, respectively. Thus, the total annual cost per obese person was NIS 300.2. This amounts to NIS 205.8 million to cover the entire obese Israeli population aged 20 and over.

Using the Israeli disease-specific QALY losses calculated in the QALY section above (pages 5–7), QALY losses averted due to decreases in mortality and reductions in morbidity were ascertained and then added together to calculate the total QALY gains due to the intervention.

To estimate the cost-utility for the individual accurately, his or her potential risk of disease must be considered. The AMI risk was used for this purpose. This index was preferred over the risks of

[2] Note that baseline data regarding waist circumference are not yet available, but presumably would also trigger dietary counseling, as above, given ethnic and gender-specific thresholds.

the other obesity-related cardiovascular system diseases incorporated into our model (viz., UAP, PVD and stroke), as it is readily calculable (National Cholesterol Education Program, 2004), and it captures at least part of the risk for multivascular disease such as stroke and PVD (Wilt et al., 1996). As it is pathophysiologically closely related to UAP risk (Tan et al., 2009), the choice of AMI rather than UAP was moot.

5.2 Pharmaceutical Interventions.

Even with the introduction of an ideal nationwide dietary program eliciting full adherence of the population, some individuals would remain obese, as dietary interventions have been successful in reducing on average only about 5% of body weight (Avenell et al., 2004). Such people are candidates for the next stage of treatment: pharmaceutical interventions (in addition to continued dietary counseling). Non-adherent obese patients are naturally also candidates for joint pharmaceutical and dietary interventions

The addition of orlistat, which acts to decrease lipid absorption from the intestine, was associated with an average weight loss of 3.26 kg (95% CI 2.37kg to 4.15 kg) after two years and beneficial changes in risk factors. In high-risk patients, it has been shown to reduce the risk for type 2 diabetes mellitus (Torgerson, 2004). Another drug, sibutramine, is a centrally acting aid to weight loss. It inhibits the reuptake of the neurotransmitters serotonin and noradrenaline, which are involved in the control of food uptake. A systematic review, based on treatment with sibutramine (Avenell et al., 2004), in addition to dietary therapy, was associated with an average weight loss of 4.12 kg (95% CI 3.26 kg to 4.97 kg) after 12 months, and beneficial changes in HDL-cholesterol and triglycerides..

The impact of BMI changes on QALYs in these pharmaceutical interventions was estimated in the literature using a variety of methods. These included measuring the direct effect of BMI reduction on well-being (Hakim et al., 2002), the impact on coronary heart disease (CHD), as estimated via the Framingham risk equation relating age/gender/BMI to risk of heart disease (Warren et al., 2004), and the reduced incidence of diabetes and its complications (Warren et al., 2004; Ruof et al., 2005).

5.3 Surgical Interventions

Persons who suffer from Class III obesity (BMI>=40) or Class II obesity (BMI>=35) coupled with an obesity-related disease should be started on a combined dietary and pharmaceutical protocol. If they fail to respond sufficiently, they then become candidates for a third level of intervention: bariatric surgery (U.S. Preventive Services Task Force, 2003).

There are various bariatric surgical procedures, which can be performed via open or laparoscopic surgery (Powers et al., 2007; Paxton and Matthews, 2005). These can be divided into malabsorptive (limiting nutrient absorption by bypassing parts of the gastrointestinal tract [Craig and Tseng, 2002] such as Roux-en Y gastric bypass surgery [RNYGBS]) and restrictive (decreasing the size of the stomach, thereby limiting food intake) procedures such as gastroplasty or gastric banding. It should be noted that RNYGBS has both the above characteristics.

A systematic review of 16 electronic databases carried out in 2001 (Pavlovich et al., 2004) found that when surgery was compared with conventional treatment, it resulted in a significantly greater average loss of weight (23–37 kg more weight loss). This loss was maintained over eight years. There were attendant improvements in quality of life and co-morbidity. Gastric bypass surgery provided an average weight loss 6–14 kg greater than either gastroplasty or jejununal bypass (Van Gemert et al., 1999). In a recent Swedish study of over 2,000 obese subjects undergoing bariatric surgery and followed up for close to 11 years, weight loss of between 14% (gastric banding) and 25% (gastric bypass) was noted. The age-gender-risk-factor-adjusted hazard ratio for mortality was 29% less in those undergoing surgery (Sjöström et al., 2007). Surgical treatment of morbid obesity is gaining in popularity due to its relative cost-effectiveness, compared with the more conservative dietary and pharmaceutical interventions (Clegg et al., 2002).

6. Coverage and Compliancy

Intervention costs, treatment, and QALY savings were based on the assumption that interventions would be aimed at the entire eligible Class II and the Class III obese population and that 100% compliance would exist at all stages of the program. In reality (especially in dietary intervention programs), compliance would fall far short of 100%. Despite this caveat, a lower compliancy rate would not significantly affect the costs per QALY ratio, since both the costs and the QALYs saved would decrease by a similar factor. Two relatively minor exceptions exist to this rule. They include any administrative overhead and a small loss to noncompliance following dispensing of pharmaceuticals.

7. Results

7.1 Dietary Interventions

Model Based on Israeli Data: Population-Wide Dietary Intervention

Appendix I shows that for all persons with a 10-year AMI risk below 7.9%, the proposed dietary intervention is cost-effective. For those with 10-year AMI risks between 7.9% and 20.5%, dietary intervention is very cost-effective. For persons with a 10-year AMI risk in excess of 20.5%, dietary interventions are actually cost-saving, as the averted treatment costs of reduced AMIs and other diseases exceed the NIS 300.2 intervention costs per person. Given the 0.00628 gain in QALY, this works out to a cost of NIS 47,796 per QALY for a person an average 10-year AMI risk of 12.8%. This happens to be the average risk of Israelis aged 55. It was chosen as an example, as it presents the age above which the incidence of coronary artery disease increases in both males and females (NHLBI, Accessed 22/11/09).

Adaptation of International Data to the Israeli Setting: Nutritional Counseling and Diet

Community Setting with a Health Care Component

A Dutch study (Bemelmans et al., 2008) modeled a large-scale community-based prevention intervention consisting of communication strategies through mass media, combined with social support such as self-help groups, risk-factor screening and counseling in various settings (modeled to be administered to 90% of the Dutch population), together with an intensive lifestyle program implemented in a health care setting (modeled to be offered to 10% of the 50% of adults who are overweight). The combined implementation would be expected to reduce the prevalence of overweight and physical inactivity by 3% and 2%, respectively, after 5 years, at an annual cost of NIS 41 per adult. The cost-effectiveness ratio would be NIS 32,521 per QALY, meaning that the intervention would be very cost-effective in an Israeli context**.**

Community vs. Health Care Settings

A Dutch lifestyle intervention model (Jacobs-van der Bruggen et al., 2007) found that the intervention costs to prevent one new case of diabetes (every 20 years) using a community-based lifestyle intervention program for the general population (range: NIS 10,774 to NIS 48,482) would be lower than those for an intensive lifestyle intervention for obese adults implemented in a health care setting (NIS 26,934 to NIS 113,124). The resultant cost per QALY for the community intervention (NIS 16,699 to NIS 21,009) would be lower than that of the health care setting intervention (NIS 21,018 to NIS 29,632). Nevertheless, both interventions should be considered very cost-effective.

Physicians

CUA studies

A systematic review (Pavlovich et al., 2004) of the literature on the cost-effectiveness of outpatient nutrition services identified one study of physician nutritional counseling for hypercholesterolemic patients in 1998 (Ockene et al., 1999). The study showed that LDL-C levels could be reduced at a cost of NIS 89 per one mmol/L (4.68 NIS per mg/dl) decrease in LDL-C. This cost was based on the net costs to the provider after savings due to decreased morbidity had been taken into account. Using the model developed for the Israeli dietary intervention (reported above), we calculated the resultant costs of the interventions per QALY gained. These, again, reflected dietary-counseling-induced reductions in the 10-year risks of AMI. Were this study to be replicated in an Israeli setting, it would be cost-saving for all 10-year AMI risks levels above 7.7%.

A study (Prosser et al., 2000) of the use of dietary therapy recommended by physicians as a primary preventive modality to lower cholesterol, reported the cost per QALY by age, gender, LDL-C level and risk groups (defined by high diastolic blood pressure level, positive smoking status and/or low HDL-C level). In general, the cost-effectiveness of the dietary intervention findings may be categorized as follows:

For males with higher levels of LDL-C ("high" LDL-C is defined as >= 130 mg/dl in otherwise healthy patients) (>4.9 mmol/L or >190-mg/dl), the intervention would be very cost-effective in all persons over 45 years old. It would be cost-effective in persons aged 35–44, irrespective of risk status.

For males with 4.2<LDL-C≤ 4.9 mmol/L (162.4<LDL-C<190 mg/dl), the intervention would be very cost-effective in all those over 35 years with more than two risk factors, and in those aged over 65 for those with one risk factor. The intervention would be cost-effective in all persons aged 35–64 years with one risk factor and in persons aged over 45 with no risk factors.

For females with high levels of LDL-C (>4.9 mmol/L or >190 mg/dl), the intervention would be very cost-effective in all those over 55 years old, and cost-effective in those aged 45–54, irrespective of risk status, as well as in those aged 35–44 with at least two risk factors.

For females with 4.2<LDL-C≤4.9 mmol/L 162.4<LDL-C<190 mg/dl), the intervention would be very cost-effective in all those aged over 75 years old and in those aged 65–74 with at least one risk factor. The intervention would be cost-effective in those aged 55–64 with one risk factor and in those aged 45–54 with at least two risk factors.

A modeled Swedish study (Hertzman, 2005) reported that 26.3% of overweight and obese patients responded to a dietary counseling regimen, losing 7.9% of their weight after a year. The intervention costs were reduced by the resultant savings due to the reduced incidence of diabetes and ensuing treatment costs. The dietary counseling intervention proved to be very cost-effective, with a cost (NIS 1,985) per QALY (0.0915 gained) ratio of NIS 21,699.

Non-CUA studies

Approximately 250 hypercholesterolemic patients were randomized to receive either intensive dietary therapy by registered dieticians through individual and group counseling or usual health care administered by general internists (Schectman et al., 1996). This study cost NIS 4,186 per one mmol/L (108 NIS per mg/dl) decrease. However, the results of this study are conservatively stated, as they are based on health care costs alone and did not consider savings due to decreased morbidity.

Physicians vs. Dieticians

CUA study

A study conducted in the United States (Pritchard et al., 1999) found the cost per kilo of weight lost to be higher in a group treated by physicians and dieticians than by dieticians alone (NIS 24 vs. NIS 17). A more recent Danish study (Olsen et al., 2005) randomized 60 general practitioner physicians (GPs) either to provide nutritional counseling or to refer patients to a dietician for counseling. Persons receiving GP counseling gained significantly more life years than those receiving counseling from a dietician (0.0919 vs. 0.0274 years). This is reflected in the lower cost per QALY of the general practitioner intervention (NIS 3,840 vs. NIS 18,698). Nevertheless, both types of interventions would be very cost-effective in an Israeli context.

Worksite Programs

Non-CUA study

A study of worksite programs in the USA evaluated the following interventions (Erfurt et al., 1991): 1. Health education (annual cost: NIS 60 per participant); 2. Health education and follow-up counseling (annual cost: NIS 262 per participant); and 3. Health education and follow-up counseling and plant organization for health promotion (annual cost: NIS 325 per participant). Though more expensive, the two studies that included counseling in addition to health education, were five to six times more cost-effective in terms of reducing health risks and preventing relapse than using health education alone. The total direct cost per percent of risks reduced/relapse prevented was only NIS2.27 and NIS2.51, for programs 2 and 3, respectively

A systematic review of 47 studies completed in 2009 for the Task Force on Community Preventive Services (Anderson, L.M. et al., 2009) showed that combined informational-educational approaches such as lectures, written materials and educational software, and behavioral interventions such as individual or group behavioral counseling, skill building activities, provision of rewards or reinforcement and inclusion of co-workers or family members to build support systems, led to weight reduction. In individually randomized controlled trials, results observed following 12 months of intervention showed that, as compared with control groups, participating employees lost an average of 2.8 pounds (1.27 kg) (9 studies) and reduced their average BMI by 0.5 units (6 studies). The range of cost-effectiveness estimates from three studies (two involving weight-loss competitions and one involving a physical fitness program) varied from NIS 13 to NIS 37 per kilo loss of body weight.

School Programs

CUA study

A school-based overweight prevention program (Brown et al., 2007) included a classroom curriculum at each grade level, a physical education program and modifications to the school food service, as well as family and home-based programs. Over three years, the program limited the increase in overweight – or at risk of overweight – boys and girls to only 1% and 2%, respectively. This compared favorably with a 9% and 13% increase in the boys and girls in the control schools. The total intervention cost was NIS 342 per child (of which approximately 37% was for health promotion costs). The 15 averted overweight cases among the 473 study children saved an average of NIS 285 in medical treatment costs and 0.181 QALYs per child. The net cost (NIS 57) per QALY saved was NIS 3,125, rendering the intervention very cost-effective in an Israeli context. In addition, the study identified a saving of NIS 557 in terms of averted future labor-productivity losses of the children. Inclusion of these averted lost productivity costs renders the project cost-saving, producing a saving of about NIS 500 per participant.

See Appendix II for dietary interventions in diabetic patients.

7.2 Pharmaceutical Interventions

General Overweight and Obese Population

Sibutramine (with Diet and Exercise)

CUA studies

A systematic health technology assessment (O'Meara et al., 2002) reported that sibutramine led to a 4.1–4.8 kg greater weight loss than placebo treatment at one year. This result was independent of the effect of dietary counseling, which was provided to both study arms. The assessment reported one manufacturer-submitted study (BASF Pharma/Knoll, 2000) that estimated the cost per QALY to be a very cost-effective NIS 75,870. However, there were concerns that side effects (small, statistically significant increases in pulse rate, heart rate and blood pressure [O'Meara et al., 2002]), were not included, thereby contributing to a downward bias of the costs per QALY. Another stated concern was that the starting utility (i.e., QALY) level of the obese cohort was significantly higher than the utility levels of the general population of the same age (O'Meara et al., 2002).

A UK study (Warren et al., 2004) focused on the health benefits gained from 12 months of treatment with sibutramine, dietary counseling and exercise. This combined protocol was chosen since, in a modeled cohort of patients (20% male) aged 18–65 years (average age, 42) with a BMI in the range of 27–40 (mean BMI=32.7kg/m^2) without co-morbidities, the European license for sibutramine prohibits prescribing to persons who have been unsuccessful in losing weight and maintaining weight loss with diet and exercise. The European license guidelines in effect at the time of the study limited continued treatment to "responders," defined as patients who lose 2 kg after 1 month of treatment and 5% of their initial weight after 3 months. The study was based on two randomized controlled clinical trials. In the first trial, sibutramine was compared with placebo and dietary counseling over a one-year period (Smith and Goulder, 2001). In the second trial, six months of treatment with sibutramine were followed by randomization to either sibutramine or to placebo and dietary counseling for a further 18 months (James et al., 2000). Both trials were based on a dose of 10mg a day, which was increased to 15mg a day if the desired weight loss was not achieved. The effect of exercise therapy was incorporated into the model in addition to the effects of sibutramine and dietary counseling from the randomized trials.

The annual cost of a sibutramine program together with dietary and exercise counseling (NIS 4,216 per person) was over two and a half times that of placebo (i.e., diet and exercise counseling alone) of NIS 1,668, after taking into account savings due to decreases in the incidence of CHD and diabetes (NIS 165 per person). QALYs were gained as a result of reductions in CHD and diabetes as well as from the higher quality of life associated with weight reduction per se. The net marginal cost of adding sibutramine (NIS 2,382 per person) per QALY gained was between NIS 40,411 (very cost-effective) and NIS 89,022 per QALY (cost-effective). Sibutramine can therefore be thought of as being a very cost-effective treatment for obesity when combined with lifestyle counseling.

A similar international study (Ara and Brennan, 2007; Brennan et al., 2006) modeled the addition of sibutramine to dietary counseling in obese persons in Germany (where the 22.9% overall prevalence of obesity in the 25–64 year age group is similar to that found in Israel). Based on utility gains from reduced incidence of CHD, diabetes and weight reduction per se (where a utility gain of 0.00375 per kilogram lost was calculated), the incremental cost per QALY of adding sibutramine was a very cost-effective NIS 83,125 per QALY.

Non-CUA studies

An American study (Malone et al., 2005) compared 281 subjects randomly assigned to receive sibutramine plus a structured weight management program (WMP) with 220 subjects who received the WMP only. The core WMP was a physician-supervised, multidisciplinary program that included five monitored care visits with a prevention specialist and attendance at two or more group-format weight management seminars. Eligible patients were aged 18 and older and were either obese (BMI≥30) or had a BMI of 27–29.9 with one or more co-morbidities.

The sibutramine group lost significantly more weight (13.7 vs. 5.0 lbs, $p<0.001$). However, this group also incurred higher median increases in annual health care costs (NIS 4,744 vs. NIS 1,005; $p<0.001$) and higher obesity-related median annual health expenditures (NIS 1,513 vs. NIS 115; $p<0.001$). Cost per QALY measures were not reported.

Orlistat and Diet

CUA studies

The licensed dose of orlistat is 120 mg, up to three times daily, as an adjunct to a mildly hypo-caloric diet in persons with a BMI≥30, or in those with a BMI≥27 with associated risk factors who have responded to a weight reducing regimen with a weight loss of at least 2.5 kg within 4 weeks. Orlistat treatment should be discontinued after 3 months if patients lose less than 5% of their initial body weight, and after 6 months if they lose less than 10% of initial body weight (National Institute of Clinical Excellence [NICE] criteria for efficacy) (O'Meara et al, 2001). The maximum licensed treatment duration was 2 years (Foxcroft, 2005)**.**

In three major European trials that included 1,398 obese individuals (Foxcroft, 2005), approximately 30% of persons taking orlistat achieved the goal of a 5% weight loss after 12 weeks, as compared with only 17.8% of those receiving placebo. A 10% weight loss after 6 months of treatment was seen in 12.8% of subjects receiving orlistat, as compared with only 5.3% of those receiving a placebo. QALY gains were based on a predicted utility gain of 0.016665 per unit decrease in BMI (O'Meara et al., 2001). The estimated cost per QALY gained was NIS 148,940 using a 12-week response criteria and NIS 197,000 using the NICE 6-month criteria. Therefore, under both response criteria, use of orlistat is considered cost-effective. These estimates are lower than a previous calculation of NIS 429,169 per QALY by the same author (which deemed orlistat not to be cost-effective) (Foxcroft and Milne, 2000.). This difference arose because the treatment algorithm used in the previous model incorrectly assumed that all patients starting on orlistat remained on the drug for 2 years, irrespective of whether they were classified after 12 weeks as non-responders (Hertzman, 2005).

An Irish study (Lacey et al., 2005) based on the pooled results of two American and three European trials (n=1,386) of at least 12 months duration, studied obese or overweight persons aged 18 years with a BMI ≥ 28kg/m^2, free of type 2 diabetes, who had shown the ability to lose 2.5 kg in weight during the introductory period. The base-case adopted a 3-year post-treatment perspective and estimated QALY gains of 0.119 for orlistat plus dietary counseling (consisting of two visits to a GP and four to a dietician for calorie-reduced diet counseling), compared with 0.091 for placebo plus identical dietary counseling. Incremental costs of adding orlistat were NIS

3,076, of which NIS 328 were recouped due to a decrease in the incidence and, hence, the costs of treating diabetes, resulting in an incremental (cost-effective) net cost of NIS 98,153 per QALY.

A modeled Swedish study quoted above in the Dietary Interventions section (Hertzman, 2005) was based on the pooled efficacy estimate that 48.9% of orlistat and dietary counseling subjects achieve the (>5%) 3-month weight goal reduction, versus only 26.3% of those receiving only dietary counseling. Responding orlistat patients had a 15.5% weight loss after a year, as compared with a 7.9% loss in the dietary counseling arm of the study. As quoted above (O'Meara et al, 2001), the predicted utility gain of 0.016665 QALYs per unit decrease in BMI was used to calculate QALY gains. The intervention costs were reduced by the resultant decreased incidence of diabetes and ensuing savings in treatment costs. The ratio for orlistat and diet was also a very cost-effective 0.122 QALYs gained for a net cost of NIS 3,380, or NIS 27,709 per QALY. The ICER of adding orlistat to diet was a very cost effective 0.0305 QALYS gained for a net cost of NIS 1,395, or NIS 45,737 per QALY.

See Appendix II for pharmacological interventions in diabetics.

7.3 Surgical Interventions

1. Bypass Surgery

1a. Gastric Bypass Surgery (GBS)

CUA study

An American cost-effectiveness analysis (Craig and Tseng, 2002) modeled GBS (costing NIS 100,143) in persons aged 35 to 54 who were free of cardiovascular disease, had a BMI of between 40 and 50 kg/m^2 and who had failed to lose weight using more conservative therapies. In persons aged 35 with a BMI of 40 kg/m^2, base case cost per QALY ratios were NIS 120,588 in males and NIS 61,980 in females. These decreased to NIS 45,115 and NIS 24,033 per QALY, respectively, in persons with BMI of 50 kg/m^2. In persons aged 55 with a BMI of 40 kg/m^2, base case per QALY ratios were NIS 150,102 in males and NIS 67,883 in females. These decreased to NIS 56,077 and NIS 22,768 per QALY, respectively, in persons with a BMI of 50 kg/m^2. These interventions were very cost-effective, with the exception of interventions for 35-year-old and 55-year-old males with a BMI of 40 kg/m^2, which were merely cost-effective.

1b. Laparoscopic Roux-en Y Gastric Bypass Surgery (LGBP) versus Open Roux-en Y Gastric Bypass Surgery (OGBP)

Non-CUA studies

Roux-en-Y gastric bypass is an example of a combined malabsorptive and restrictive procedure whereby the stomach is reduced to a small gastric pouch connected to a segment of jejunum downstream, bypassing the duodenum and proximal small intestine, thereby reducing nutrient absorption (Powers et al., 2007). Laparoscopic surgery is a minimally invasive form of surgery utilizing a small incision, usually 0.5–1.5 cm, as compared to traditional "open" surgery, which requires larger incisions. Advantages of laparoscopic surgery include reduced pain, reduced hemorrhaging and shorter recovery times, In a U.S. study (Siddiqui et al. 2006), modeled success rates were tracked over a one-year follow-up period. Rates were higher with LGBP than with OGBP in all the BMI groups: 86% vs. 82% in those with a BMI between 35 to 49, 82% vs. 77% in those with a BMI between 50 to 60, and 67% vs. 63% in those with a BMI >60. Mortality in the OGBP group was 30% higher for BMIs from 36 to 60 (1.4% vs. 1.1% for LGBP), and 22% higher when BMI exceeded 60 (2.8% vs. 2.3%). Although the initial LBGP operating room costs were also higher (NIS 23,480 vs. NIS 17,334), overall one-year treatment costs (including operating room costs) were lower: NIS 95,163 vs. NIS 111,281 (BMI 35 to 49), NIS 115,401 vs. NIS 138,187 (BMI 50 to 60) and NIS 123,918 vs. NIS 160,169 (BMI>60). No costs per QALY were calculated as LGBP dominated OGBP. It may be concluded that for all BMI ranges, LGBP is preferable to OGBP.

This finding was strengthened when a review of actual data on 5,867 LGBP (average BMI=48.4, age 41.4 years, 16.4% males) and 6,425 OGBP (average BMI=51.4, age 39.0 years, 13.9% males) patients found that OGBP was associated with a significantly higher incidence of major perioperative complications, especially extraintestinal complications, and greater perioperative mortality (Paxton and Matthews, 2005). LGBP was associated with shorter hospital stays (2.5 vs. 3.7 days) despite an increased incidence of intestinal complications. No significant differences in loss of excess weight were noted at the three-year follow-up. LGBP was associated with increased surgical (NIS 21,625 vs. NIS 15,964) and overall hospital costs (NIS 32,162 vs. NIS 29,688). In addition, there was an extra cost of NIS 260 associated with the 2.25% of persons requiring conversion to OGBP. However, these extra costs were more than offset by LGBP savings of NIS 13,056 in complication costs (NIS 17,188 vs. NIS 18,839, which included fewer work absences), mortality associated costs (NIS 6,558 vs. NIS 12,047) and income lost to routine recovery (NIS 9,336 vs. NIS 15,252). Overall, total costs of LGBP were NIS 10,323 lower than OGBP (NIS 65,504 vs. NIS 75,827). As LGBP was cheaper and since LGBP patients suffered fewer (expensive) life-threatening complications, LGBP was considered a cost-effective alternative to OGBP. No attempt was made to calculate costs per QALY in that study, which included both direct and indirect costs.

2. Gastroplasty

2a. Vertical Banded Gastroplasty (VBG)

CUA study

Quality of life was assessed on a small number (n=21) of morbidly obese persons in the Netherlands before and after VBG. VBG resulted in increased longevity of 3.6 years and improved quality of life, reflected by an overall gain of 12 QALYs over a lifetime compared with non-surgical care (Van Gemert et al., 1999). Total direct costs of VBG of NIS 38,439 were exceeded by lifetime treatment savings of NIS 51,569 due to lower morbidity and mortality costs. Participation in the paid labor force increased from 19% before VBG to 48% after VBG, resulting in an increased productivity gain of NIS 17,497 per year. Employee work absences also decreased by almost 75%. VBG was recommended for introduction as it results in a QALY gain at no extra costs (i.e., it is cost-saving), whether viewed from a narrow health services or a wider societal perspective.

2b. Vertical Banded Gastroplasty (VBG) vs. Laparoscopic Banded Surgery (LBS)

Non-CUA study

In another Dutch study (Van Mastrigt et al., 2006), 100 morbidly obese patients (average BMI = 46.6) were randomly assigned to either VBG or LBS. Surgical costs of VBG were significantly lower than LBS costs (NIS 10,898 vs. NIS 25,106, respectively). Overall costs after 12 months, including direct and indirect medical costs as well as non-medical costs, were NIS 85,726 for VBG and NIS 73,472 for LBS (i.e., no significant difference). Approximately half of these costs were related to hospitalization and re-hospitalization. VBG patients lost a higher percentage of excessive weight (71.7% vs. 53.9%, p=0.001). The incremental cost per percent of excessive weight loss when moving from LBS to VBG was NIS 586. No costs per QALY were calculated in the paper.

3. Comparison of Surgical and Other Modalities

3a. Usual Care vs. VBG vs. Gastric Bypass (GBS) vs. Silicone Adjustable Gastric Banding (SAGB)

CUA study

A cost-utility analysis (Clegg at al., 2002) with a 20-year time horizon, based on parameters reported in the literature (Clegg et al., 2003), reported the costs of interventions varying from NIS 2,392 for usual care, NIS 22,948 for VBG, NIS 23,732 for open GBS, NIS 24,152 for Laparoscopic GBS, NIS 31,685 for laparoscopic adjustable gastric banding, to NIS 33,842 for SAGB. Average cost-effectiveness ratios (ACER) were all very cost-effective, varying from NIS 4,415 per QALY for usual care to NIS 6,581 per QALY for SAGB (Table 5).

Table 5: ACERs and ICERs for Surgical Interventions for Morbid Obesity

	Net Cost (NIS)	QALYs Gained	Average Cost (NIS) per QALY	ICER cf. Usual Care (NIS) per QALY
Usual care	49,585	11.23	4,415	-
VBG	68,546	11.49	5,966	72,890
GBS	69,522	11.67	5,957	44,779
SAGB	76,863	11.69	6,581	60,714

As indicated in Table 5, all the ICERs associated with moving from usual (non-surgical) care to surgical care were very cost-effective, as were the ICERs (not shown in the table) of moving from VBG to SAGB – NIS 43,770 per QALY, calculated by (NIS 76,863-68,546)/(11.69-11.49 QALY) – or moving from VBG to GBS (only NIS 5,422 per QALY calculated as above). The ICER of moving from GBS to SAGB was not cost-effective in the least, reaching NIS 734,093 per QALY. GBS appears to be the most cost-effective option, but it should be noted that the newer SAGB technique was still in the developmental stage at the time of the analysis (Van Gemert, et al., 1999).

For data on obese diabetic patients undergoing gastric bypass and adjustable gastric binding, see Appendix III.

Table 6: Summary of Cost-Utility Ratios Ranked by NIS per QALY (at 2008 Cost Levels)
(ICERs presented *in italics* if available.)

Intervention	Comparator	Ref.	Key	NIS per QALY
DIETARY COUNSELING				
Cost-saving interventions				
Physician	No intervention	Ockene 1999	(b)	**CS**
Very cost-effective interventions				
School-based	No intervention	Brown 2007	(c)	3,125
General practitioners	No intervention	Olsen 2005	(c)	3,840
Dietician	No intervention	Olsen 2005	(c)	18,698
Community with intensive lifestyle	No intervention	Jacobs-van der Bruggen 2007	(c)	18,854
Doctors and dieticians (meta-analysis)	No intervention	Hertzman 2005	(c)	21,699
Health care setting with intensive lifestyle	No intervention	Jacobs-van der Bruggen 2007	(c)	25,314
Community with intensive lifestyle	No intervention	Bemelmans 2008	(c)	32,521
Dietician for severely obese (standard diet)	No intervention	Tsai 2003	(c)	36,652
Dietician for severely obese (low carbohydrate diet)	No intervention	Tsai 2003	(c)	37,439
GP (50%), Nurse (25%), Dietician (20%), Psychologist (5%)	No intervention	This article	(a, d)	47,796
PHARMACEUTICAL				
Healthy obese				
Very cost-effective interventions				
Sibutramine, diet, exercise counseling	*Diet and exercise*	*Warren 2004*	*(c)*	*40,411-89,022*
Orlistat, dietary counseling	*Dietary counseling*	*Hertzman 2005*	*(c)*	*45,737*
Sibutramine – manufacturer's submission	Placebo	BASF 2000	(c)	75,870
Sibutramine, dietary counseling	*Dietary counseling*	*Ara 2007*	*(c)*	*83,125*
Cost-effective interventions				
Orlistat, dietary counseling (5 pooled studies)	*Dietary counseling*	*Lacey 2005*	*(c)*	*98,153*
Orlistat	Placebo	Foxcroft 2005	(c)	148,940-197,000
Diabetic obese				
Cost-saving interventions				
Metformin	*Conventional control*	*Palmer 2000*	*(c)*	*Metformin dominates*

Intervention	Comparator	Ref.	Key	NIS per QALY
Very cost-effective interventions				
Orlistat	Placebo	Maetzel 2003	(b)	50,061
Exenatide and Metformin	*Metformin*	*Watkins 2006*	*(c)*	*56,942*
Orlistat	Placebo	Lamotte 2002	(c, e)	22,304-127,450
Orlistat, diet and physical activity management	*Placebo, diet and physical activity management*	*Ruof 2005*	*(c)*	*87,326*
SURGICAL				
Cost-saving interventions				
Vertical Banded Gastroplasty, 33 yr olds, BMI=47.2, 95.2% Females	No intervention	Van Gemert 1999	(c)	**CS**
Very cost-effective interventions				
Gastric Bypass, 35 yr olds, BMI=50	No intervention	Craig 2002	(c, f)	34,574
Gastric Bypass, 55 yr olds, BMI=50	No intervention	Craig 2002	(c, f)	39,422
Gastric Bypass, 40 yr olds, BMI=45	*Non-surgical care*	*Clegg 2002 Clegg 2003*	*(c)*	*44,779*
Adjustable Gastric Banding, 40 yr olds, BMI=45	*Non-surgical care*	*Clegg 2002 Clegg 2003*	*(c)*	*60,714*
Vertical Banded Gastroplasty 40 yr olds, BMI=45	*Non-surgical care*	*Clegg 2002 Clegg 2003*	*(c)*	*72,890*
Gastric Bypass, 35 yr olds, BMI = 40	No intervention	Craig 2002	(c, f)	91,784
Cost-effective interventions				
Gastric Bypass, 55 yr olds, BMI = 40	No intervention	Craig 2002	(c, f)	108,992
Diabetic obese				
Cost-saving interventions				
Gastric bypass	*Conventional treatment*	*Ackroyd 2006*	*(c)*	*CS to 9,442*
Adjustable Gastric Banding	*Conventional treatment*	*Ackroyd 2006*	*(c)*	*CS to 11,990*

Notes: CS = Cost Saving

(a) Based on primary Israeli epidemiological, demographic and cost data, efficacy from meta-analysis of international studies.

(b) Based on primary Israeli epidemiological and demographic data, cost data updated and converted to Israeli 2008 price levels, efficacy from international study.

(c) Based on international data converted to Israeli 2008 price levels.

(d) Based on cost per QALY at average 10 year AMI risk of 12.8% at age 55.

(e) Based on cost per life-year gained for various baseline risk-factor levels.

(f) Based on average of male and female values.

8. Discussion

Obesity is a serious and expensive risk factor for many chronic diseases, generating total direct costs of about NIS 1.14 billion to the Israeli economy. This is equivalent to approximately 0.16% of the country's GDP or approximately 2% of its health expenditure.

8.1 Dietary Interventions

Our survey of the international literature (see Table 6) shows that *almost every dietary intervention was very cost-effective in the Israeli context*. Implicit in the dietary intervention model is the assumption that the effectiveness attained in overseas studies will be replicated within the Israeli population. As noted above, we assumed 100% reach and population compliancy. In a non-trial situation, it is not known what the real compliancy rate would be. However, as noted above, in the Methods section, reducing this figure does not measurably impact on the cost-utility calculation, as both the numerator (cost) and the denominator (QALYs saved) are reduced by similar proportions.

Our primary model was based on the effects of diet on blood LDL-C levels using Israeli data. This marker of weight loss captures only part of the preventive potential of dietary interventions, as it does not include savings that accrue from diseases such as diabetes mellitus, hypertension, gall bladder disease, endometrial cancer and pulmonary embolism. Therefore, the estimated costs per QALY have been overestimated.

In addition, only direct health costs have been factored into the calculations. Inclusion of indirect cost savings would very likely further increase the cost-effectiveness of our recommendations.

Using the reduction in hyperlipidemia and the resulting impact on vascular system morbidity and mortality confirms that the intervention can be very cost-effective. The model defines the ranges where interventions are cost-effective. Under the constraints of a very strict decision-making algorithm that limits interventions to only those that are cost-saving and using AMI risk as a proxy for risk of chronic disease, it is clear that dietary counseling should be provided to all obese persons with a 10-year AMI risk higher than 20.5%. Provision of this intervention on a countrywide basis would target between 70,000 and 120,000 obese persons aged 21 and older and would cost between NIS 21.0 million and NIS 36.1 million. Yet it would save between NIS 32.0 million and NIS 55.0 million in treatment costs, resulting in a net saving of NIS 11.0 million to 18.9 million. In addition to saving between NIS 11.0 million and NIS 18.9 million in resources, this intervention would provide between 327 and 559 additional QALYs annually.

Less strict decision-making criteria could be used to provide counseling only to those groups whose cardiovascular risk profile renders interventions delivered to them either cost-saving or very cost-effective, i.e., obese persons with a 10-year risk higher than 7.9%. Provision of this intervention on a national basis would target between 279,000 and 480,000 obese persons aged 21 and older and would cost between NIS 83.7 million and NIS 143.9 million, but it would save treatment costs of between NIS 75.4 million and NIS 129.6 million, resulting in net program costs between NIS 8.3 million and NIS 14.3 million. Between 1,045 and 1,754 QALYs would be gained annually by this intervention at an average cost of between NIS 7,956 and NIS 8,155 per QALY.

However, results from dietary studies lasting longer than 6 months show that weight regain may be common (Tsai and Wadden, 2005). Therefore, maintenance programs are essential in order to sustain the weight loss. Assuming the effectiveness seen in short-term studies holds for the long-term/maintenance intervention period, we assume that the additional QALYs generated and treatment costs saved would compensate for the additional maintenance costs.

Outside the health care environment, it has been shown that single or multi-component behavioral interventions in children and adolescents to reduce screen time (time spent watching TV, videotapes, or DVDs; playing video or computer games; and surfing the Internet) have led to moderate weight loss (Task Force on Community Preventive Services, 2008). It should be noted that a recent systematic review has reaffirmed the effectiveness of worksite nutrition and physical activity interventions (Anderson, L.M., 2009). A recent simulation cost-minimization model of workplace obesity interventions suggested that low cost policy or environmental changes at the workplace could be cost-saving (Trogdon et al., 2009).

A lone study also found that combination school programs including a classroom curriculum, a physical education program and modifications to the school food service, as well as family- and home-based programs were very cost effective and even became cost-saving when future productivity savings were taken into account (Brown et al., 2007).

Due to the paucity of cost-utility studies, *there is insufficient evidence to make any recommendation that would further refine our dietary counseling recommendations along the lines of a particular diet, using a particular type of caregiver or focusing on the health care vs. the work environment for adults.*

8.2 Pharmaceutical Interventions

Sibutramine was shown to be a very cost effective intervention with an ACER of 76,000 and an ICER ranging from NIS 40,000 to NIS 89,000 per QALY if sibutramine was added to dietary-counseling weight-management interventions (Table 6).

Two of three cost-effectiveness studies of orlistat showed it to be cost-effective with an ACER ranging from NIS 148,940–NIS 197,000 and an ICER of NIS 98,153, when orlistat was added to dietary counseling, as compared with dietary counseling alone. A third study showed orlistat to be very cost-effective with an ICER of NIS 45,737 when added to dietary counseling.

A systematic health technology assessment (O'Meara et al., 2001) confirmed orlistat's advantage over placebo in terms of weight loss and lipid and blood pressure improvements. The review noted the higher incidence of gastrointestinal adverse events associated with orlistat use.

Therefore, since no CUA analysis explicitly took into account the higher incidence of gastrointestinal adverse events, costs per QALY using orlistat may be slightly underestimated.

In obese diabetics (see Appendix II), metformin dominated conventional care, as it was both cheaper and more effective. In turn, the ICER of adding exenatide to existing metformin therapy was a very cost-effective NIS 57,000 per QALY (Table 6). The ACER for treatment with orlistat was shown to range from a very cost-effective NIS 50,000 to a cost-effective NIS 127,000, while the ICER of adding it to dietary and exercise interventions was a very cost-effective NIS 87,000.

In summary, *pharmaceuticals range from being a very cost-effective to a cost-effective intervention* to reduce obesity (see Table 6). If 50% of the obese population who received dietary counseling failed to respond, then 333,619 would be directed to drug therapy. Assuming half of the interventions include sibutramine (at a cost of NIS 12.94 per day) and the other half orlistat (NIS 5.77 per day), the total annual costs would amount to about NIS 1.186 million. Such an intervention would provide between 9,534 and 24,743 QALYs to Israeli society at an average cost of between NIS 48,853 and NIS 124,340 per QALY.

A caveat regarding drug safety is warranted: As is true of many medications, these two medications are known to cause side effects. The U.S. FDA recently requested that the manufacturers of sibutramine (Meridia in the U.S.) add a new contraindication to the drug label stating that the drug is not to be used in patients with a history of cardiovascular disease (FDA, 2010)

8.3 Surgical Interventions

Morbidly and very obese persons who have not responded to pharmaceutical and/or dietary interventions seek surgical interventions to improve their health and their quality of life. In general, *these interventions have been shown to range from cost-saving to cost-effective*, depending on the specific intervention and the population at risk (Table 6).

Gastric bypass surgery was either very cost-effective or cost-effective, depending on the age and the BMI of the individual concerned. Laparoscopic surgery was more cost-effective than open abdominal surgery. Banded gastroplasty was found to range from being cost-saving to very cost-effective, from a health-service and societal perspective.

Overall, gastric bypass appears to be the most cost-effective option, but the newer gastroplasty techniques are still at the developmental stage (Van Gemert et al., 1999). In morbidly obese diabetics (BMI $\geq$ 40), gastroplasty and bypass surgery were cost-saving and very cost-effective, respectively, compared with conventional treatment.

Under the assumptions that operations are split equally between gastric bypass (NIS 33,000) and vertical gastric banding (NIS 25,000), the cost of providing surgery to 1,000 persons with a BMI>=40 (or >=35 with additional obesity-related risk factors) amounts to roughly NIS 29 million. Assuming the cost per QALY falls in the range from NIS 34,574–NIS 72,890 (as stated above vis-à-vis these two types of surgery), this would provide between 344 and 867 additional QALYs per 1,000 persons undergoing surgery. These operations can, of course, be spread over a number of years to reduce annual expenditures.

9. CONCLUSION

The cost-utility of three interventional modalities for the prevention and treatment of obesity was determined. Generally, the ratios were found to be either cost-saving or very cost-effective: dietary counseling tended to be either cost-saving or very cost-effective, pharmaceutical interventions either very cost-effective or at least cost-effective, while the various surgical interventions ranged from being cost-saving to cost-effective, contingent upon the specific technique and the study. Generally speaking, these three modalities incrementally address ever more obese/difficult to treat populations. As such, they tend not to compete with one another.

Within each treatment modality, differences in cost-effectiveness were noted, but the data are not robust enough to facilitate within-modality prioritization at this point.

This report confirms the cost-effectiveness of several interventions already funded to some degree in the basket of health services. These include dietary counseling for the obese or severely overweight with additional risk factors. Surgical interventions are funded only for those with Class III obesity or Class II obesity with risk factors. On the other hand, pharmaceutical interventions, such as sibutramine and orlistat are not funded, but as they too have been shown to be very cost-effective, they should be considered for funding pending review of their effectiveness/safety profile.

Israeli interventional research to reduce and control obesity in a variety of settings is critical to inform decision-making on the basis of local effectiveness and cost-utility findings.

Each of these obesity interventions will need to compete for scarce resources with the many interventions available for the prevention and treatment of the myriad of diseases and to reduce the prevalence of risk factors extant in the population. The cost-utility ratios reported in this study provide important objective evidence to inform health policymaking.

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Appendix I: Cost (NIS) per QALY of a Modeled Dietary Counseling Intervention in Israel by 10-Year AMI Risk

Ten Year AMI risk	Cost (NIS)/ QALY
0.5%	**153,917**
1.5%	**146,495**
2.5%	**139,073**
3.5%	**131,651**
4.5%	**124,230**
5.5%	**116,808**
6.5%	**109,386**
7.5%	**101,964**
8.5%	*91,583*
9.5%	*81,201*
10.5%	*70,820*
11.5%	*60,438*
12.5%	*50,057*
13.5%	*42,521*
14.5%	*34,985*
15.5%	*27,449*
16.5%	*19,913*
17.5%	*12,376*
18.5%	*8,284*
19.5%	*4,192*
20.5%	*100*
21.5%	- 3,992
22.5%	- 8,084
23.5%	- 11,213
24.5%	- 14,341
25.5%	- 17,470
26.5%	- 20,598
27.5%	- 23,727
28.5%	- 26,196
29.5%	- 28,665
30.5%	- 31,134
31.5%	- 33,603
32.5%	- 36,072
33.5%	- 37,985
34.5%	- 39,897
35.5%	- 41,810
36.5%	- 43,722
37.5%	- 45,635
38.5%	- 47,215
39.5%	- 48,796
40.5%	- 50,376
41.5%	- 51,956

Ten Year AMI risk	Cost (NIS)/ QALY
42.5%	- 53,536
43.5%	- 54,864
44.5%	- 56,192
45.5%	- 57,519
46.5%	- 58,847
47.5%	- 60,175
48.5%	- 61,306
49.5%	- 62,437
50.5%	- 63,568
51.5%	- 64,699
52.5%	- 65,830
53.5%	- 66,805
54.5%	- 67,780
55.5%	- 68,756
56.5%	- 69,731
57.5%	- 70,706
58.5%	- 71,862
59.5%	- 73,017
60.5%	- 74,173
61.5%	- 75,329
62.5%	- 76,484
63.5%	- 77,212
64.5%	- 77,940
65.5%	- 78,668
66.5%	- 79,396
67.5%	- 80,124
68.5%	- 80,769
69.5%	- 81,414
70.5%	- 82,059
71.5%	- 82,704
72.5%	- 83,349
73.5%	- 83,924
74.5%	- 84,499
75.5%	- 85,074
76.5%	- 85,649
77.5%	- 86,225
78.5%	- 86,800
79.5%	- 87,375

LEGEND
Bold font: Intervention is cost-effective
Italic font: Intervention is very cost-effective
Normal font: Intervention is cost-saving

Source: Ginsberg, G.M. 2008. ***Model for Assessing Cost-Utility of Decreases in LDL-C***. Ministry of Health, Jerusalem, 2008.

Appendix II: Dietary and Pharmaceutical Interventions for Obese and Overweight Diabetic Patients

Obesity is a risk factor for developing diabetes. Cost utility studies have also been carried out on the significant subgroup of obese and overweight persons who are also diabetics**.**

a. Dietary Intervention

Low-Carbohydrate vs. Standard Diet in Severely Obese High Risk Subjects

In a U.S. study, 129 severely obese subjects (BMI = 42.9) with a high prevalence of diabetes or metabolic syndrome (Tsai et al., 2003) were allocated to a low-carbohydrate or a standard diet, costing NIS 23,961 and NIS 22,209, respectively. Despite this extra cost – arising from extra work time losses required for participants to attend a greater number of dietary counseling sessions – there was no significant difference in the average QALYs experienced in the two groups (0.64 and 0.61, respectively).

b. Pharmaceutical Interventions

Metformin

A model in a Swiss setting compared the cost-effectiveness of managing overweight type-2 diabetics with either conventional glycemic control (primarily with diet) or using intensive control with metformin (Palmer et al., 2000). In the 11-year follow-up period, mean net costs per patient (discounted at 3% per annum) were NIS 30,374 and NIS 27,641 for conventional and metformin control, respectively. In addition, metformin added 0.34 QALYs (discounted at 3%). Consequently, metformin dominates conventional control, as it is both cheaper and more efficacious.

Exenatide vs. Metformin

Exenatide is used as adjunctive therapy to improve glycemic control in type 2 diabetes mellitus patients (Watkins et al., 2006). Along with small decreases in glycosylated hemoglobin (HbA1c) levels, a statistically significant weight loss of 2–3 kg was observed in clinical trials. The incremental cost-effectiveness ratio (ICER) compared with no additional treatment (metformin only) based on a time horizon of 20 years, was very cost-effective, being only NIS 56,942 per QALY.

Orlistat

A study of orlistat in overweight and obese diabetic patients (Lamotte et al., 2002) reported incremental costs per life-year gained of between NIS 22,304 and NIS 127,450, depending on the baseline cardiovascular risk factors. After converting these costs per life-year to costs per QALY, most of the scenarios of orlistat use are still likely to be very cost-effective, with the remainder being cost-effective.

Orlistat and Standard Therapy (i.e., Metformin, Sulphonlyurea or Insulin) and Weight Management Strategies

Data were pooled from 7 randomized controlled clinical trials (n=2479) of orlistat in overweight and obese patients with type 2 diabetes (Ruof et al., 2005). At the end of the 12-week study period, 23% of orlistat patients achieved a weight reduction of more than 5%. These responders showed a mean weight reduction of 8.6kg, a 5.3% reduction in their total cholesterol levels, and a 5.2 mmHg reduction in systolic blood pressure. ICER costs per QALY gained were very cost effective, at NIS 87,326 per QALY.

A Markov model based in the USA (Maetzel et al., 2003), simulated diabetes-related complications and mortality for 11 years. Patients were modeled to continue orlistat therapy for a one-year period, followed by a three-year period of weight regain, where after three years their body weight would match that of the placebo group. The impact of orlistat on HbA1c levels was evaluated using data from four randomized controlled trials. Treatment with 120mg orlistat thrice daily increased event-free life expectancy by 0.13 years. Average treatment costs were NIS 84,272 in the treatment group compared with NIS 61,811 in the group that received diabetes medication and weight management (calorie reduced diet and exercise) alone. Based on an average remaining lifetime-adjusted disability weight for a 55-year-old (Lamotte et al., 2002) in Israel (WHO, 2002) of 0.30 (corresponding to an average QALY of 0.70), costs per QALY in the orlistat treatment group were a very cost-effective NIS 20,901 per QALY, compared with a very cost-effective NIS 20,201 per QALY in the control group. The ICER for adding orlistat, at a cost of NIS 4,731 NIS for a gain of 0.094 QALYs, was very cost-effective, at NIS 50,061 per QALY.

APPENDIX III: SURGICAL INTERVENTIONS FOR OBESE DIABETIC PATIENTS

Gastric Bypass and Adjustable Gastric Binding

A collaborative study (Ackroyd et al., 2006) modeled the QALY scores based on BMI and diabetic status, utilization data from the literature and treatment costs for adjustable gastric binding (AGB), gastric bypass surgery (GBS) in comparison with conventional treatment (CT) in the UK, Germany and France over a 5 year period. CT was based on experience of current practice in the countries. The CT consisted of watchful waiting and medically guided dieting. Compared to CT, GBS yielded 80.8 kg/m^2 years (i.e., BMI on average 16.16 $kg.m^2$ lower for each of the 5 years) and 2.6 more diabetes-free years (due to remissions). AGB yielded 57.8 kg/m^{2-} years, and 2.5 more diabetes-free years (due to remissions).

In Germany (Ackroyd et al., 2006), both GBS (NIS 72,455) and AGB (NIS 81,391) were cheaper than CT (NIS 102,842) due to the decrease in treatment costs, and provided 1.34 and 1.04 more QALYs respectively, so they are said to dominate CT. It should be noted that GBS dominates AGB, as it is both cheaper and provides more QALYs.

Similarly, in France (Ackroyd et al., 2006) both GBS (NIS 72,755) and AGB (NIS 81,391) were cheaper than CT (NIS 102,842) and provided more QALYs, thus dominating CT. Again, the cheaper GBS modality dominates AGB.

In the UK (Ackroyd et al., 2006), GBS (NIS 56,775) and AGB (NIS 56,470) were more expensive than CT (NIS 44,120), yielding a very cost-effective ICER of NIS 9,444 and NIS 11,990 per QALY, respectively. GBS, was very cost-effective compared with AGB, having a cost (NIS 305) per QALY (0.30 more) ratio of only NIS 984 per QALY. Assuming a baseline utility of 1.87 over five years (Anderson. 1999, Lacey et al., 2005) for an untreated morbid obese person, the ACER for CT was not cost-effective, at NIS 334,870. However, the ACER for GBP (NIS 38,576 per QALY) and AGP (NIS 48,607 per QALY) were very cost-effective.

APPENDIX IV: GLOSSARY OF ABBREVIATIONS

ACER: The average cost-effectiveness ratio relates the net costs of the intervention (compared with a do-nothing scenario) to the gain in QALYs due to the intervention. The ACER is used to answer the question whether the intervention is worthwhile per se.

AGB: Adjustable gastric binding

AMI: Acute myocardial infarction

BMI: Body Mass Index = weight in kg/[height in meters]^2)

CBS: Central Bureau of Statistics in Jerusalem

CHD: Coronary heart disease

CUA: Cost-utility analysis

CVA: Cerebrovascular event, commonly known as a stroke

GBS: Gastric bypass surgery

HALE: Health-adjusted life expectancy, otherwise known as healthy-years equivalent (HYE), is a health outcome measure that combines preferences for quality of life and quantity of life into a single metric. It is the hypothetical number of years spent in good health, which is considered equivalent to the larger actual number of years spent in a defined imperfect state of health or in a series of defined imperfect states of health.

HRQL: Health-related quality of life

ICER: The incremental cost-effectiveness ratio relates the incremental net costs of the intervention (compared with another intervention) to the incremental gain in QALYs (compared with another intervention) as a result of the intervention. The ICER provides decision-makers with information regarding the financial cost to be incurred when implementing an alternative intervention to achieve a known increase in QALYs.

LBS: Laparoscopic banded surgery

LDL-C: The cholesterol in low-density lipoproteins

LGBP: Laparoscopic roux-en Y gastric bypass surgery

NICE: National Institute for Clinical Excellence

OGBP: Open roux-en Y gastric bypass surgery

PAF: The population attributable fraction is the reduction in incidence that would be observed if the population were entirely unexposed, compared with its current (actual) exposure pattern. PAF can be thought of as the percentage of the disease burden (incidence) that is due to the risk factor.

PPP: Purchasing Power Parity – This purchasing power rate equalizes the purchasing power of different currencies in their home countries for a given basket of goods. Using a PPP basis is arguably more useful when comparing differences in living standards on the whole between nations because PPP takes into account the relative cost of living and the inflation rates of different countries, rather than just a nominal gross domestic product (GDP) comparison.

PVD: Peripheral vascular disease

PYLL: Potential years of life lost – the number of years of life lost due to premature death. This is equivalent to life expectancy at that age, had the person not died prematurely.

QALY: A quality-adjusted life year is a universal health outcome measure applicable to all individuals and all diseases, thereby enabling comparisons across diagnoses and across programs. A QALY combines, in a single measure, gains or losses in both quality of life (morbidity) and quantity of life (morbidity).*

RR: Relative risk is a measure used to predict the likelihood of disease in exposed individuals relative to those who are unexposed.*

SAGB: Silicone Adjustable Gastric Banding

UAP: Unstable Angina Pectoris

VBG: Vertical banded gastroplasty

WHO: World Health Organization

WMP: Weight management program

*As defined in Berger, M.L.; Bingefors, K.; Hedblom, E.C.; Pashos, C.L.; and Torrance, G. (eds.). 2003. ***Health Care Cost, Quality, and Outcomes. ISPOR Book of Terms***. ISPOR.