



Myers-JDC-Brookdale Institute  
Smokler Center for Health Policy Research



State of Israel  
Ministry of Health

# COST-UTILITY ANALYSES OF INTERVENTIONS TO INCREASE PHYSICAL EXERCISE IN ISRAELI ADULTS

Gary Ginsberg ♦ Elliot Rosenberg

*in collaboration with*  
Bruce Rosen



RR-565-11



# **COST-UTILITY ANALYSES OF INTERVENTIONS TO INCREASE PHYSICAL EXERCISE IN ISRAELI ADULTS**

**Gary Ginsberg**  
*Ministry of Health,  
Medical Technology Assessment Sector*

**Elliot Rosenberg**  
*Ministry of Health  
Healthy Israel 2020 Initiative*

*in collaboration with*  
**Bruce Rosen**  
*Myers-JDC-Brookdale Institute*

Jerusalem

June 2011

Editor: Naomi Halsted

Hebrew translation (executive summary and publication announcement): Jenny Rosenfeld

Layout and print production: Leslie Klineman

**Myers-JDC-Brookdale Institute**  
Smokler Center for Health Policy Research  
P.O.B. 3886  
Jerusalem 91037, Israel

Tel: (02) 655-7400

Fax: (02) 561-2391

Web site: [www.jdc.org.il/brookdale](http://www.jdc.org.il/brookdale)



## Related Myers-JDC-Brookdale Institute Publications

Ginsberg, G.; Rosen, B.; and Rosenberg, E. 2010. *Cost-Utility Analyses of Interventions to Reduce the Smoking-Related Burden of Disease in Israel*. RR-540-10.

Ginsberg, G. in collaboration with Rosen, B. and Rosenberg, E. 2010. *Cost-Utility Analyses of Interventions to Prevent and Treat Obesity in Israel*. RR-550-10.

These publications do not appear in print, but they are available on the Institute website:  
[www.jdc.org.il/brookdale](http://www.jdc.org.il/brookdale)

To order other Institute publications, please contact the Myers-JDC-Brookdale Institute, P.O.B. 3886, Jerusalem, 91037; Tel: (02) 655-7400; Fax: (02) 561-2391; E-mail: [brook@jdc.org.il](mailto:brook@jdc.org.il)

## Executive Summary

Physical inactivity (or sedentariness) is a serious and expensive risk factor for many chronic diseases. Approximately NIS 1.5 billion in direct healthcare costs may be attributed to sedentariness in Israel in 2008. This represents 0.21% of Israel's GNP.

Cost-utility ratios of interventional modalities for increasing physical activity were calculated by incorporating local Israel epidemiologic, economic and demographic parameters into published international analyses.

Public health interventions such as those delivered at schools and worksites were not covered, as the literature does not provide sufficient information to calculate generalizable cost-utility analyses.

Cost-saving interventions are defined as those where 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).

Primary preventive interventions based on the Green Prescription program (which incorporates intensive GP training in motivational interviewing with telephone follow-up by exercise specialists) and the STEP Test Exercise Prescription (based on exercise counseling and prescription of an exercise training target heart rate) and patient counseling, as well as pedometer use and mass media-based campaigns, were found to supply additional QALYs at no additional net cost, and thus were cost-saving. Others interventions, such as Internet-based campaigns, community programs to increase pedometer use and joint mass-media-based/community activity campaigns were also found to be cost-saving. Transport programs to encourage walking, paid media advertisements, public relations events with worksite, church, and local organizations, exposure to dedicated websites, supervised group exercise classes, and GP-delivered exercise advice were found to be very cost-effective in an Israeli healthcare setting. Eight more interventions were found to be cost-effective.

In addition, many tertiary interventions assessed for patients with such diseases as coronary artery disease, diabetes mellitus and osteoarthritis were either cost-saving or very cost-effective.

Adopting a variety of the many cost-saving or very cost-effective interventions delineated in this review will enable us to attain the Healthy Israel 2020 target to decrease sedentariness by 9.3 percentage points (i.e., reducing the population prevalence of sedentariness from 71.3% to 62%) and would save the health services nearly NIS 197 million, as well as prevent considerable losses of productivity due to absenteeism and lower productivity.

## **Acknowledgments**

This work has been made possible thanks to the generous funding of a donor who wishes to remain anonymous. We also thank Naomi Halsted, who edited this report, and Leslie Klineman, who prepared it for publication.

# Table of Contents

1. Introduction	1
1.1 International Prevalence of Sedentariness and Attributable Burden of Disease (BOD)	1
1.2 Prevalence of Sedentariness in Israel and Attributable BOD	2
1.3 Economic Burden of Inactivity	2
1.4 Effectiveness of Primary Prevention	3
1.5 Current Physical Activity Recommendations	3
1.6 Types of Interventions	4
1.7 The Case for Prioritization	4
2. Study Goals	4
3. Methods	4
3.1 Adapting International Studies	5
3.2 Adjusting Economic Parameters	6
3.3 Costs and Savings of Interventions	6
3.4 Efficacy Coverage and Compliance	7
3.5 Definitions	7
4. Results	7
4.1 Intermediate Outcome Studies	7
4.2 Health Outcome Studies	8
4.3 Studies with Insufficient Primary Data	16
5. Discussion	20
Bibliography	23
Appendix I: Tertiary Prevention	32
Appendix II: Net Cost per QALY of Tertiary Prevention Interventions versus Comparators	33
Appendix III: Cost-Saving Tertiary Prevention Interventions versus Usual Care	35
Appendix IV: Very Cost-Effective and Dominated Tertiary Prevention Interventions versus Usual Care	36
Appendix V: Glossary of Terms and Abbreviations	37

## List of Tables

Table 1:	Net Cost per HALY Saved by Exercise Training, by Age and Gender	8
Table 2:	Costs and QALYs Gained per Person in Cost-Saving Primary Prevention Interventions (ranked by Net Societal Cost) versus Usual Care	13
Table 3:	Very Cost-Effective Primary Prevention Interventions versus Usual Care (ranked by Net Societal Cost per QALY)	14
Table 4:	Cost-Effective and Non-Cost-Effective Primary Prevention Interventions versus Usual Care (ranked by Net Societal Cost per QALY)	19
Table II-1:	Tertiary Prevention Interventions versus Comparators (ranked by Net Cost per QALY)	34
Table III-1	Cost Saving Tertiary Interventions versus Usual Care (ranked by Net Cost Saved)	35
Table IV-1:	Very-Cost-Effective and Dominated Tertiary Prevention Interventions versus Usual Care (ranked by Net Cost per QALY)	36

# 1. Introduction

In 2005, the Ministry of Health established the Healthy Israel 2020 project. Since then, some 300 professionals have been involved in the process through contributing to 20 different committees. Three sub-committees of the Health Behaviors Committee focused on the areas of obesity control, smoking control and enhancement of physical activity, and they have recommended several effective interventions in each area. Evidence of the effectiveness of an intervention is indeed a crucial step in determining whether it should be adopted, but there needs to be a mechanism for prioritizing these interventions. Effectiveness alone is an insufficient basis upon which to make such recommendations. Cost-utility analysis (CUA) is a well-established tool used for this purpose.

CUA combines the disciplines of epidemiology, medicine and economics in order to rank projects according to the cost per QALY (quality-adjusted life year) saved. It is now used by many countries throughout the world as a necessary – albeit not sufficient – tool in determining health service priorities (other factors such as equity, political pressure, etc., may 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 a level playing field, thus overcoming the universal phenomenon where health systems tend to be dominated by persons working in curative as opposed to preventive medicine.

This report augments the work done by the Physical Activity sub-committee of the Healthy Israel 2020 Health Behaviors Committee. It is the last of a trilogy that also provides estimates of the CUA of various interventions for the prevention and treatment of obesity and for decreasing tobacco-related diseases. The results should enable standardized comparisons (described in the Methods section) to be made between interventions to enhance physical activity and as well as facilitate prioritization between these and those recommended to address other health behaviors.

## 1.1 International Prevalence of Sedentariness and Attributable Burden of Disease (BOD)

Physical inactivity is a substantial preventable risk factor for mortality in developed countries, carrying a relative risk of death of around 1.5 compared to physically active persons of both genders (Oguma et al., 2002). As a risk factor for several chronic diseases, sedentariness constitutes a major public health burden.

The prevalence of absolute physical inactivity among adults is estimated to be 17% worldwide, while 41% are underactive (i.e., engage in <2.5 hours per week of activity of moderate intensity) (WHO, 2002). The term sedentariness applies to people who are totally physically inactive or physically underactive. In terms of the burden of disease (BOD), physical inactivity causes about 1.9 million deaths annually and the loss of 19 million disability-adjusted life years (DALYs) globally (WHO, 2002). It is estimated to cause 10–16% of all cases of breast, colon and rectal cancer and diabetes mellitus worldwide, and about 22% of ischemic heart disease (WHO, 2002). Physical inactivity or sedentariness is one of the ten largest risk factors for premature death in developed countries (WHO, 2002).

Within the Organization for Economic Co-operation and Development (OECD), whose membership includes over 30 of the world's most developed countries, physical inactivity is estimated to cause 12% of all mortality, 8% of all life years lost as a result of premature mortality,

2% of life years lost as a result of morbidity, and 5% of the total burden of disease (National Institute of Public Health, Sweden, 1999).

The WHO has estimated that 80% of heart and cardiovascular diseases, 90% of non-insulin dependent diabetes and 30% of all cancers can be prevented through implementation of lifestyle changes (WHO, 2002). These include adopting a healthy diet, quitting smoking and engaging in the desired amount of physical activity (WHO, 2002).

In recent years, there has been an increase in structured exercise activities (e.g., sports clubs, fitness centers, aerobic dance classes) in developed economies. However, this does not fully compensate for the decrease in physical activity in the workplace and during travel to and from work (King, 1999). To illustrate this point, it is useful to understand just how sedentary the developed world has become. People from Western countries would need to walk an additional 19 kilometers every day to expend as much energy as do people in a typical South American tribe (Cordain et al., 1998).

## **1.2 Prevalence of Sedentariness in Israel and Attributable BOD**

Currently, 28.7% of Israeli adults (aged 18–65) engage in physical activity at least three times a week (National Health Survey, 2003–2004). The Healthy Israel 2020 Initiative target for this population for the year 2020 is to increase the prevalence by an absolute increase of 9.3% (Ministry of Health, 2009) to 38.0%.

Cross-country comparisons of physical inactivity have to be made with great caution, because of the various different definitions of physical inactivity that have been used. Based on a UK definition that physical inactivity occurs when adults are physically active for more than 30 minutes a day on fewer than five days a week, 40% of UK males and 28% of UK females are considered to be physically active (NHS Information Center, 2008). An international study (Bauman et al., 2009) defined persons with low or moderate physical activity to meet any of the following criteria: (a) fewer than 4 days of vigorous activity of at least 20 minutes per day; (b) fewer than 6 days of moderate-intensity activity or walking; (c) fewer than 6 days of a combination of (a) and (b), achieving less than 600 MET-minutes a week. By this complicated definition, 32.8% and 43.2% of men and women aged 18–65 in the USA had low or moderate physical activity. Comparative figures were 33.5% and 45.1%, respectively (for Canada) and 34.3% and 48.6%, respectively (for Australia).

## **1.3 Economic Burden of Inactivity**

In the 1990s, it was estimated that about two-thirds of Canadians were physically inactive (Katzmarzyk et al, 2000). Physical inactivity prevalence and summary relative risk (RR) estimates from prospective longitudinal studies of the effects of physical inactivity on stroke, colon cancer, breast cancer, type 2 diabetes and osteoporosis were used to compute the population attributable fraction (PAF) of physical inactivity for each illness. About CAD \$2.1 billion (range: CAD \$1.4–\$3.1 billion) or 2.5% (range: 1.7%–3.7%) of the total direct health costs of Canada were attributable to physical inactivity in 1999. It is estimated that in 1995, roughly 21,000 lives were lost prematurely due to physical inactivity (Katzmarzyk et al, 2000). After adjusting for differences in physical activity rates and purchasing power between Canada and Israel, this translates into NIS 1.5 billion (range: NIS 1.0 billion–NIS 2.2 billion) in direct health costs that may be attributed to

physical inactivity in Israel in 2008. This figure represents 0.21% (range 0.14% - 0.31%) of Israel's GNP.

#### **1.4 Effectiveness of Primary Prevention**

Physical exercise has been shown to reduce overall mortality, cardiovascular diseases, strokes, colon, breast, prostate, uterine and lung cancer, type 2 diabetes, metabolic syndrome, depression, dementia and Alzheimer's disease (Thune and Furber, 2001). At the same time, physical exertion can sometimes have adverse affects such as muscular-skeletal injuries and cardiovascular events (Thune and Furber, 2001).

Aerobic exercise training (for 30 minutes at least 3 times a week) in a population of 35–74 year olds reduced cardiovascular risk factors such as low-density lipoprotein (LDL) cholesterol by 4%, increased high-density lipoprotein (HDL) by 5%, and decreased systolic and diastolic blood pressure by about 6 mmHg (Wendel-Vos et al., 2004). Many well-conducted cohort studies have also highlighted the long-term health benefits of physical activity (Lee and Skerrett, 2001; Thune and Furbur, 2001; Wendel-Vos et al., 2004).

Physical activity was shown to be very cost-effective when modeled in a 35-year-old male cohort in the form of jogging (Hatzian greu et al., 1988) and in males of various age groups (Hall, 2006). Exercise has also often been included as a component in multiple risk factor interventions for preventing coronary diseases (Ebrahim and Smith, 1997) along with diet, smoking cessation and other lifestyle interventions. Given the convincing scientific evidence that physical inactivity leads to a host of chronic degenerative conditions and premature death, the promotion of a physically active lifestyle is an important public health goal.

#### **1.5 Current Physical Activity Recommendations**

The latest 2008 guidelines from the United States Department of Health and Human Services (U.S. Dept of Health and Human Services, 2008) follow:

- ◆ All adults should avoid inactivity. Some physical activity is better than none, and adults who participate in any amount of physical activity gain some health benefits.
- ◆ For substantial health benefits, adults should do at least 150 minutes (2 hours and 30 minutes) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity, aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. Aerobic activity should be performed in episodes of at least 10 minutes, and preferably, it should be spread throughout the week.
- ◆ For additional and more extensive health benefits, adults should increase their aerobic physical activity to 300 minutes (5 hours) a week of moderate intensity, or 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity. Additional health benefits are gained by engaging in physical activity beyond this amount.
- ◆ Adults should also do muscle-strengthening activities that are moderate- or high-intensity and involve all major muscle groups on 2 or more days a week, as these activities provide additional health benefits.

- ◆ When older adults cannot do 150 minutes of moderate-intensity aerobic activity a week because of chronic conditions, they should be as physically active as their abilities and conditions allow.
- ◆ Older adults should do exercises that maintain or improve balance if they are at risk of falling.
- ◆ Older adults should determine their level of effort for physical activity relative to their level of fitness.
- ◆ Older adults with chronic conditions should understand whether and how their conditions affect their ability to do regular physical activity safely.

## 1.6 Types of Interventions:

A myriad of potential interventions and combinations of interventions aim to reduce the burden of primary and tertiary disease due to sedentariness. The two major interventional categories are health-provider counseling in the clinic and interventions in the workplace and the community.

## 1.7 The Case for Prioritization

As is the case in many countries (European Observatory on Health Systems and Policies, accessed 2009), there is a perception that in Israel, too, preventive interventions are underfunded relative to curative care. This may be due to a variety of reasons, including the misconception that preventive interventions, and specifically those to enhance physical activity, are either less effective or less cost-effective than therapeutic interventions, perhaps due to the longer time lag between the actual intervention and the ultimate health benefit generated by the intervention. The policy challenge lies first in proving that many of these interventions are indeed at least as cost-effective as those in the therapeutic realm, and secondly, determining which interventions have the best cost-utility ratio.

## 2. Study Goals

The goal was to assist Israeli policymakers in their efforts to prioritize interventions to encourage physical exercise in Israeli adults by calculating cost-effectiveness ratios of relevant interventional modalities.

## 3. Methods

A literature search was carried out by searching the MEDLINE database using the following algorithm: (("physical exercise" or "exercise programs" or "exercise interventions" or "exercise program" or "exercise programmes" or "exercise programme" or "physical activity") AND (cost-benefit or "cost benefit" or cost-effectiveness or "cost-effectiveness" or cost-utility or "cost utility")). This was supplemented by any additional articles found referenced in the articles retrieved from the above algorithm.

Interventions set in the following settings were retrieved:

- ◆ Health clinics
- ◆ Community
- ◆ Home
- ◆ Worksite

in addition to hospital-based settings for tertiary prevention (see appendices).

The following intervention modalities were included:

- ◆ Individual counseling
- ◆ Group counseling
- ◆ Media interventions
- ◆ Environmental interventions
- ◆ Financial incentives.

The basic formula used for calculating the cost per QALY was

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

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 disease incidence and mortality due to the intervention.

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

This analysis primarily provides estimates of the Average Cost-Effectiveness Ratio (ACER) of each intervention. The ACER relates the net costs of the intervention (compared with a do-nothing scenario) to the gain in QALYs as a result of the intervention. Using the ACER answers the question of 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 comparing a typically new intervention ("A") versus the existing intervention ("B").

### **3.1 Adapting International Studies**

The data on costs per QALY from international studies should ideally 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 expectancy
- ◆ Gender specific HALE (health-adjusted life expectancy)
- ◆ Period in which the study was performed.

We assumed no significant differences existed in QALY weights for specific diseases between Israel and other developed countries. We made adjustments to as many of the above factors as possible, subject to data constraints, in order to convert values from international literature to Israeli estimates. The few studies that presented their results in terms of cost per life-year added had the life-years converted to HALEs by applying WHO age and gender-specific interpolated estimates of Israeli HALEs at age 0 and 65. In most cases, however, there was a lack of access to the original epidemiological data sets. Therefore, estimates were converted to the Israeli setting through adjustment of the economic parameters only.

### **3.2 Adjusting Economic Parameters**

Foreign currency costs were converted to 2008 Israeli shekels (NIS) price levels based on the health or consumer price index of the country concerned (U.S. Dept. of Labor, Bureau of Labor Statistics, 2008). Labor costs (representing non-tradable goods) were converted into 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, 1.81 per Swiss franc, 2.07 per New Zealand dollar, 2.27 per Australian dollar, 0.388 per Swedish kroner and 0.022 per Japanese yen. 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 were labor costs. For interventions that were based purely on counseling, the labor component was assumed to be 90% of the total costs. For interventions and savings based purely on drug costs, the international exchange rate was used, as these are internationally tradable goods.

### **3.3 Costs and Savings of Interventions**

Several major components should ideally be incorporated when addressing CUAs. These include the costs of the intervention, and the various savings that accrue as a result of reduced morbidity and mortality and improved functioning. The latter includes the following direct and indirect savings:

- ◆ Healthcare (GP visits, hospital care, medications, rehabilitation, etc.)
- ◆ Lost productivity costs due to absenteeism and presenteeism
- ◆ Premature burial costs (i.e., current burials cost more than the discounted cost of future burials)
- ◆ Home and community costs (improved functionality reduces the need for social services required due to a person's inability to perform daily activities in their home, especially for the elderly)
- ◆ Transportation costs for treatment (including those of caregivers).

In the present study, we have included health-service-related costs such as hospitalization and pharmaceutical costs as well as costs falling outside the healthcare system, where available.

All calculations were based on a 2008 mid-year Israeli population of 7,302,100 persons (Eddy et al., 2005). Data on employment costs of health service staff were provided by the Budgeting Department of the Ministry of Health, with physician costs increased by 24.4% to reflect the latest pay award in November 2008.

### 3.4 Efficacy Coverage and Compliance

Since Israel is a small country whose inhabitants are covered by national health insurance, we assumed that any new nationwide program would be offered to all of the population. The paucity of Israeli-based physical activity adherence data (Epel and Ziva Regev, 2000; Dubbert et al., 2002) impeded our ability to obtain data of sufficient external validity to attempt to adjust the CUAs data of interventions reported from other countries. Implicit in our use of secondary cost-utility calculations is the assumption that efficacy and adherence rates in Israel would be similar to those experienced in the country of origin of the study. Obviously, due to a multiplicity of socio-cultural, ethnic, economic, psychological, structural and organizational factors, there is no way of knowing if actual efficacies generated in an Israeli context would be higher, similar or lower than those reported abroad. Due to the lack of available primary data from actual Israeli interventions, we are forced to rely on the only available data, i.e., efficacies generated by foreign studies in developed countries.

### 3.5 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 very cost-effective and cost-effective if the cost per QALY is less than the per capita GNP (NIS 97,700 in 2008) or 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 per capita GNP (>NIS 293,100), the intervention is regarded as not being cost-effective (WHO Commission on Macroeconomics and Health, 2001). If the savings from the reduction in treatment costs are larger than the intervention costs, then the program is said to be cost-saving.

## 4. Results

### 4.1 Intermediate Outcome Studies

We identified many studies that were defined as cost-effective studies, but did not present results using a cost-utility format (i.e., using QALYs), as they only reported intermediate outcomes or suffered from other shortcomings (Dalziel and Segal, 2007). Examples follow:

- ◆ A randomized, controlled trial of a primary care GP-based 10-week physical activity intervention in 45–74-year-old men and women in London (Stevens et al., 1998), found that it cost NIS 24,000 to move one sedentary adult to an "active state."
- ◆ Individualized exercise advice from a GP, combined with group nutritional counseling, which cost approximately NIS 300 and led to a weight loss of 6.7 kilos, had an incremental cost-effectiveness ratio of NIS 45 per kilo lost at 12-month follow-up (Pritchard et al., 1999). However, flaws in effectiveness data prevented a full cost-utility analysis from being performed (Dalziel and Segal, 2007).
- ◆ A nurse-delivered home exercise program to prevent falls in elderly men and women (age 80 and over) in New Zealand cost NIS 4,144–NIS 5,000 per fall prevented to deliver the program, and only NIS 430 per fall prevented when averted hospital costs were considered (Robertson, Devlin, Gardner et al., 2001; Robertson, Gardner et al., 2001). A similar study in women aged 80 and older reported delivery costs of cost only NIS 759 per fall prevented (Robertson, Devlin, Schuffman et al., 2001).

- ◆ A center-based lifestyle intervention for sedentary community-dwelling adults in the USA was offered. It consisted of integrated behavioral modification and cognitive behavior modification techniques tailored to the participants' level of motivational readiness for change. This was found to be more cost-effective than a structured exercise intervention that included receipt of a typical exercise prescription under the supervision of a health educator at a state-of-the-art fitness facility. The lifestyle intervention reduced systolic blood pressure at a cost of NIS 23 per month per mmHg reduction, while the structured exercise prescription cost NIS 114 NIS per month per mmHg reduction (Sevick et al., 2000).

## 4.2 Health Outcome Studies

### Costs per HALY (Health-Adjusted Life Year) (Table 1)

A model-based calculation of the effects of unsupervised and supervised exercise training for the primary and tertiary prevention of cardiovascular disease (CVD) mortality is presented in Table 1. Unsupervised exercise training was estimated to be very cost-effective in terms of costs per HALY for males aged 35–74 (European Observatory, 2009). For females, the intervention was also considered very cost-effective, except in females aged 55–64 with CVD, where it was found to be cost-saving. A supervised exercise program was more expensive to deliver and proved cost-effective for both genders in healthy subjects; in males aged 55–64 it was even *very* cost-effective. Conversely, in females aged 65–74 it was not found to be cost-effective. In those with CVD, the supervised exercise program was very cost-effective (except in females aged 35–54, where it was found to be only cost-effective). The results were sensitive to the compliancy rates, which in the baseline case were assumed to be 50% (during the first year) and 30% (in subsequent years). These figures underestimate the true cost per HALY, as they do not include the HALY gains due to the effect of exercise on morbidity decreases.

**Table 1: Net Cost (2008:NIS) per HALY Saved by Exercise Training, by Age and Gender**

	Age	Males		Females	
		Unsupervised	Supervised	Unsupervised	Supervised
Without CVD	35-54	8,181	111,446	34,542	193,910
	55-64	1,291	79,052	21,819	234,771
	65-74	12,628	111,000	38,429	299,320
With CVD	35-54	6,129	48,491	23,023	144,183
	55-64	1,148	28,828	-2,037	38,603
	65-74	5,606	47,061	2,982	62,759

Notes:

- ◆ Net costs include initial physical test, clothing, footwear and group exercise class.
- ◆ Net costs also include deduction for savings in treatment costs.
- ◆ As noted in European Observatory on Health Systems and Policies, 2009, calculations only include benefits from reductions in CVD.
- ◆ Adherence was assumed to be 50% in the first year and 30% in subsequent years.
- ◆ Calculations are based on lifetime age and gender-specific HALE) for Israel.
- ◆ The model assumes 10% less HALE for those with CVD.

## **Cost-Saving Interventions (Table 2)**

### ***Clinical Preventive Interventions***

The Step Test Exercise Prescription (STEP) project (Petrella et al., 2003) included exercise counseling and prescription of an exercise training target heart rate. The project determined the effect of an exercise prescription instrument (STEP) compared to usual care exercise counseling delivered by primary care doctors on fitness and exercise self-efficacy among elderly community-dwelling patients. It incorporated a randomized controlled trial with baseline assessment and intervention delivery with post-intervention follow-up at 3, 6 and 12 months. A total of 284 healthy community-dwelling patients aged >65 years registered in four large, academic primary care practices in the USA were recruited in 1998–1999. A total of 241 subjects (131 in the intervention group and 110 controls) completed the trial. VO<sub>2</sub>max was significantly increased in the STEP intervention group (11% vs. 4% at 6 months and 14% vs. 3% at 12 months [ $p<0.0001$ ]). A similar significant increase in exercise self-efficacy (32% vs. 22%) was observed for the STEP group compared to the control group at 12 months ( $p<0.001$ ). Systolic blood pressure decreased 7.3% and body mass index decreased 7.4% in the STEP group, with no significant change in the control group ( $p<0.05$ ).

The STEP trial data (along with data from many other trials consisting of brief intervention in primary care and exercise referral) was inputted into an economic-epidemiological model commissioned by the UK-based National Institute for Clinical Excellence (NICE) (NICE, 2006). The model incorporated the following estimates from the literature:

1. The incremental costs of the intervention to the UK public sector
2. The impact of the interventions on physical activity levels
3. The impact of these activity levels on participants' relative risk (based on studies matched by age and gender) of experiencing morbidity and mortality due to coronary heart disease, stroke, diabetes and colon cancer
4. The impact of experiencing these diagnoses on the participants' quality of life
5. The health costs of treating these diagnoses, based on UK public sector data. (This was actually an underestimate as no treatment costs were available for colon cancer.)

The cost of the intervention per participant was NIS 250; however, savings of NIS 3,274 accrued from decreased treatment costs as a result of decreased morbidity. On average, each participant gained 0.57 QALYs and, in the long term, saved NIS 3,024.

The second program that was cost-saving was the Green Prescription program (Elley et al., 2003), which incorporated intensive GP training in motivational interviewing with telephone follow-up by exercise specialists. A cluster controlled trial randomized 42 rural and urban practices in New Zealand before systematic screening and recruitment of patients. The subjects were all sedentary 40–79-year-old patients who visited their general practitioner during the study's recruitment period. Patients receiving the intervention used a form given by the researcher to prompt their general practitioner or practice nurse during the consultation to deliver the Green Prescription program. For the intervention, the GPs were prompted by the patient, thus jointly providing oral and written advice on physical activity. Exercise specialists continued support by telephone and post. Control

patients received usual care. At the 12-month follow-up, the mean total energy expenditure had increased by additional 9.4 kcal/kg/week (P=0.001) and leisure exercise by an additional 2.7 kcal/kg/week (P=0.02) or 34 minutes/week in the intervention group relative to the control group (P=0.04). The proportion of the intervention group engaging in 2.5 hours/week of leisure exercise increased by 9.72% (P=0.003) more than in the control group. SF-36 measures of self-rated "general health," "role physical" (degree of problems with work or other daily activities as a result of physical health),"vitality" and "bodily pain" improved significantly more in the intervention group (P<0.05). A trend towards decreasing blood pressure became apparent, but there was no significant difference in four-year risk of coronary heart disease.

The following paragraphs present three different cost-effectiveness analyses all based on the Green Prescription program:

A cost-effectiveness analysis (Elley et al., 2004) of the Green Prescription program estimated the program cost per patient in New Zealand to be NIS 449. The incremental cost of converting one sedentary adult to an active state over a 12-month period was NIS 4,625.

A cost-utility analysis (using a 5% instead of a 3% discount rate) of the Green Prescription program used SF-36 scores to estimate utilities of 0.7635 for active persons and 0.7380 for inactive states. This resulted in a modeled lifetime gain of 0.079 QALYs (baseline scenario) or 0.122 QALYs (based on simulations to take skewness of the data into account). The incremental intervention cost was NIS 413 (to the health services) and NIS 488 (taking societal costs into account). Based on data on treatment savings of NIS 494 in the post-intervention year from a companion article (Elley et al., 2004), it may be concluded that a small net cost savings of NIS 81 from a health services perspective and NIS 6 from a societal perspective could be derived from the intervention.

Based on the NICE methodology described above with UK unit costs (NICE, 2006), the Green Prescription program (Elley et al., 2003) cost NIS 12,114 for each person who reached the physical activity threshold. Cost of the intervention per participant was NIS 1,176; however, savings of NIS 7,229 accrued from decreased treatment costs, as a result of decreased morbidity. These estimated cost savings were considerably larger than that found in the actual study (Elley et al., 2004) as they were based on modeled lifetime estimates as opposed to changes in the post intervention year. On average, each participant gained 0.45 QALYs, and in the long-term (over a lifetime) saved NIS 6,053 in resources.

### ***Community Interventions***

Community programs can be used to increase physical activity. One such intervention was in Queensland, Australia, where the Rockhampton Project was an exemplary model of an effective multi-strategy, multi-sector physical activity project. The project successfully motivated local communities, workplaces and individuals to encourage pedometer use in persons aged 15 years and older, as a motivational tool to increase physical activity to 10,000 steps a day (Cobiac et al., 2009; Eakin et al., 2007). Increases in physical activity (PA) levels were achieved by: Raising state/national awareness of the health benefits of moderate PA; strengthening the capacity of GPs and other health professionals to promote PA; strengthening the capacity of communities within the state/nation to provide improved opportunities; promoting social support, policies and environments for PA; and strengthening the capacity of individuals to be more active by addressing modifiable individual risk factors. Based on a meta-analysis of eight randomized controlled trials, such

programs achieved a QALY gain of 0.0077 per targeted person aged 15 years and above (Cobiac et al., 2009; Bravata et al., 2007). The intervention cost of NIS 56 NIS per person (Cobiac et al., 2009; Brown et al., 2006) was more than offset by estimated NIS 487 savings in treatment costs (over a lifetime), giving a net savings of NIS 431 per participant.

A six-week campaign in Australia combined physical activity promotion via mass media (television, radio, newspapers etc.), distribution of promotional materials, and community events and activities. This campaign (Elley et al., 2004; Dalziel et al., 2006) achieved a QALY gain of 0.0025 per targeted person aged 25–60. The intervention cost of NIS 3 per person (Dalziel et al., 2006; Cobiac et al., 2009) was more than offset by an estimated NIS 114 savings in lifetime treatment costs, giving a net savings of NIS 111 per participant.

### **Additional Less Rigorous Findings**

A community-level intervention took place in the UK among 260 men and women aged 40–70 (Lamb et al., 2002). All participants attended a 30-minute seminar led by a physiotherapist in which they were advised to engage in 120 minutes of moderate-intensity physical activity per week (supplemented by general written guidance). People randomized to the health walks group received verbal and written information about the health walks program from the initial seminar and were encouraged to consider this as an option for increasing physical activity. They were referred to the local walk coordinator who contacted them up to three times by telephone to invite them to specific walks. The control group did not receive the health walks information or referral.

A higher proportion of the study group increased their activity to above 120 minutes of moderate-intensity activity per week (35.7% vs. 22.6% in the control group,  $p=0.05$ ) at 12 months. However, an intent-to-treat analysis, using the last known value for missing cases, demonstrated smaller differences between the groups, with the only study group having a (non-significant) 6% higher activity rate (95% CI -5%–16.4%). There were improvements in the total time spent and the number of occasions of moderate-intensity activity and in aerobic capacity, but no statistically significant differences between the groups. Other cardiovascular risk factors remained unchanged. Based on the NICE methodology described above with UK unit costs (NICE, 2006), which was based on those actually participating in the program (as opposed to the intent-to-treat analysis) such a program (Lindgren et al., 2003) generated 0.31 QALYs per participant and had an incremental cost for the health walks component of NIS 149 for each person who reached the physical activity threshold. However, savings of NIS 5,074 accrued from decreased treatment costs as a result of decreased morbidity, leaving a net savings of NIS 4,925 per participant. As this result was not based on an intent-to-treat analysis, it was omitted from Table 2 (cost-saving interventions).

Receiving brief verbal advice during a consultation with a GP and a written exercise prescription (Swinburn et al., 1998) was particularly effective (generating an average QALY gain of 1.01). NICE estimated the intervention cost to be only NIS 122 per person, which was well covered by treatment savings of NIS 20,694, resulting in a net intervention savings of NIS 20,572. However, this intervention was omitted from Table 2 as it was based on optimistically extrapolating from improvements seen over a short follow-up period of 6 weeks to the long term (Swinburn et al., 1998).

Data from five other cost-saving interventions identified by NICE (NICE, 2006) relating to interviews with health visitors (Harland et al., 1999) and Primary Care Physicians (PCPs) (Smith et al., 2000), were also omitted from Table 2 as neither promoted long term physical activity. The "Active Script Program" (Sims et al., 2004) was also omitted from Table 2 since it was not derived from a controlled study of effectiveness, but rather from a small sample self-reported pre-post study of physicians with an even smaller sample of patients.

No cost-utility analyses of increasing physical activity in children have yet appeared in the scientific literature. Hence, school-based interventions are not covered in this report.

**Table 2: Costs and QALYs Gained per Person in Cost-Saving Primary Prevention Interventions (Ranked by Net Societal Cost) versus Usual Care (NIS 2008)**

Study	Intervention	QALYS Gained	Gross Interv'n Cost (a)	Gross Societal Cost (b)	Treatment Savings	Net Cost (c)	Net Societal Cost (d)
NICE/Elley	Green Exercise Prescription from GP vs. usual care (e)	0.452	1,176	–	7,229	-6,053(f)	
Cobiac/Bravata	Pedometers vs. null	0.0077	56	56	487	-43(f)	-431
Cobiac/Bauman	Mass Media vs. null	0.0025	3	3	114	-111(f)	-111
Dalziel/Elley (g)	Green Exercise Prescription from GP vs. usual care (e)	0.122	413	488	494(g)	-81(h)	-6
Dalziel/Elley (i)	Green Exercise Prescription from GP vs. usual care (e)	0.079	413	488	494(g)	-81(h)	-6
NICE Petrella	STEP Test Exercise Prescription and patient counseling from GP vs. usual care counseling	0.571	250	–	3,274	-3,024(f)	–

(a) Intervention cost alone

(b) Intervention cost including productivity and possibly travel costs

(c) Gross intervention cost less treatment savings

(d) Gross societal costs less treatment savings

(e) Green Exercise Prescription with intensive GP training in motivational interviewing with telephone follow-up by exercise specialists

(f) Lifetime time horizon

(g) Result based on mean of 1,000 simulations to take into account the skewed nature of some of the data

(h) One-year time horizon

(i) Baseline case from Markov model

**Table 3: Very Cost-Effective Primary Prevention Interventions versus Usual Care (NIS 2008) (ranked by Net Societal Cost per QALY)**

Very Cost Effective		QALYS Gained	Gross Intervention Cost (a)	Gross Societal Cost (b)	Net Cost (c)	Net Societal Cost (d)	Gross Cost per QALY	Gross Societal Cost/QALY	Net Cost/QALY	Net Societal Cost per QALY
Cobiac/Kosma /Napolitano/ Plotnikoff	Internet vs. null	0.0019	124	124	18(e)	18	66,486	66,486	9,730	9,730
Cobiac/Elley	Green Exercise Prescription from GP vs. null	0.0037	275	310	88(e)	99	75,067	84,676	23,974	27,042
Cobiac	TravelSmart transport program that encourages walking vs. null	0.0008	87	87	40(e)	40	105,806	105,806	49,032	49,032
Roux	Paid media advertisements, public relations events and activities at worksites, church and local organizations, exposure to a dedicated website to encourage walking, and physician prescriptions to walk 30 minutes, 5 days a week to encourage walking vs. null	0.049	–	–	–	2,707(e)	–	–	–	55,248
Munro	Supervised group exercise classes vs. control group(f, g)	0.011	920	933	920(h)	933	83,643	84,859	83,643	84,859
Lindgren	GP delivered exercise advice to 60 year olds vs. null	0.017	–	–	1,343(e)	1,472	–	–	79,005	86,567

(a) Intervention cost alone

(b) Intervention cost including productivity and possibly travel costs

(c) Intervention cost less treatment savings

(d) Gross societal costs less treatment savings

(e) Lifetime time horizon

(f) Trial recorded only the 26% of elderly persons who attended at least one session

(g) Based on the summary significant statistic resulting from one significant result out of the nine dimensions measured (i.e., eight were non-significant)

(h) Two-year time horizon

### **Very Cost-Effective Interventions (Table 3)**

The following nine studies present interventions that are very cost-effective, all of them supplying QALYs for a cost lower than per capita GNP.

The first three studies were based on applying efficacy rates to cost data in an Australian context (Cobiac et al., 2009).

Firstly, participants were recruited via the mass media to access physical activity information and advice across the Internet via a website and/or e-mail. The target group was derived from participation and attrition rates in three randomized controlled trials (Kosma et al., 2005; Napolitano et al., 2003; Plotnikoff et al., 2005) and Australian Internet access statistics. The effect was derived from a meta-analysis of the increase in minutes per week walking in the three trials. An average of 0.019 QALYs were gained per targeted person at an intervention cost of NIS 124 per person. However, most of this cost (NIS 105) was recouped in treatment savings (over a lifetime), leaving a net cost of only NIS 18, giving a net cost per QALY of NIS 9,730 (Cobiac et al., 2009).

The second study was in effect the Average Cost Effectiveness Ratio (ACER) of the Green Prescription study (Elley et al., 2003; Elley et al., 2004). This study (described in the previous section) was found to be cost-saving with respect to usual care. However when compared to a do-nothing "null," the additional net cost of NIS 99 per participant (derived from NIS 310 intervention costs less NIS 211 treatment savings) supplied 0.037 QALYs per participant (aged 40–79) at a cost per QALY of NIS 27,042 (Cobiac et al., 2009).

The third study was an active transport program (TravelSmart) that targeted households with tailored information (e.g., maps of local walking paths, bus timetables) and merchandise (e.g., water bottles, key rings) as an incentive and/or reward for reducing the use of cars for transport. The intervention effect was derived as a weighted average of the increase in walking and cycling trips per week observed in 21 TravelSmart studies. As compared to a do-nothing "null," the additional net cost of NIS 40 per participant (derived from NIS 87 intervention costs less NIS 47 treatment savings (over a lifetime) supplied 0.0008 QALYs per participant (aged over 15 years) at a cost per QALY of NIS 49,032 (Cobiac et al., 2009).

Roux (Roux et al., 2008) evaluated the cost-effectiveness of 7 physical activity interventions embodying at least one of four strategies strongly recommended by the Task Force on Community Preventive Services: Community-wide campaigns, individually accepted health behavior change, community social support interventions and the creation of enhanced physical activity information and opportunities. Each intervention was compared to a no-intervention alternative. A systematic review of the impact of physical activity level on disease burden from coronary heart disease (CHD), ischemic stroke, type 2 diabetes, breast cancer and colorectal cancer was conducted to allow calculation of healthcare cost savings. Only one intervention of the 7 examined was very cost-effective. This was based on a community campaign (Reger et al., 2002) using paid media (TV, radio, newspapers, websites, billboards), public relations and public health activities at worksites, churches and local organizations to encourage walking among sedentary older adults aged 50–65. An average of 0.059 QALYs were gained at a lifetime cost of NIS 2,707 per participant, giving a cost per QALY of NIS 55,248.

Munro reported a later study (Munro et al., 2004) carried out in Sheffield, Yorkshire (UK) and incorporating the work of 12 general practices (4 intervention practices and 8 controls). The participants were all individuals over 65 in the least active four-fifths of the population. There were 2,283 participants from intervention practices and 4,137 from control practices. A letter was sent inviting respondents to indicate an interest in attending local exercise sessions led by an experienced exercise leader on a twice-weekly basis. There were no significant differences in 3-year all-cause mortality rates, however for exercise-related conditions there was a (non-significant) suggestion of lower mortality in the exercise arm. There were no significant differences in health service usage, hence treatment savings were valued as zero with both gross and net societal costs (based on a 2-year time horizon) being NIS 933 per patient. Patients in the intervention practices had a slower decline in health status than the controls in every SF-36 dimension, although this reached conventional levels of significance only in the energy dimension. QALY gains were around 0.011 per intervention participant, giving a net societal cost per QALY of NIS 84,859.

Lindgren (Lindgren et al., 2003) used a Markov model to predict reduction in CHD events based on risk-factor reductions. The study evaluated the results of a controlled trial of 60-year-old men in Stockholm that compared the effects of dietary advice, exercise and a combination of both. Patients underwent a physical checkup during a visit to a physician. After randomization, they received advice on diet and/or exercise from the physician. Patients receiving dietary advice also visited a dietician. Patients in the exercise group were asked to maintain a prepared activity log and were given the opportunity to join exercise groups. Patients were followed up at 6 and 18 months. For exercise alone, the net societal lifetime cost of NIS 1,472 provided a QALY gain of 0.017 QALY per participant, resulting in a cost per QALY of NIS 86,567. Interestingly, the model predicted lower costs and higher effectiveness for dietary advice compared to either physical exercise or combined dietary advice and physical exercise.

### **4.3 Studies with Insufficient Primary Data**

Annemans (Annemans et al., 2007) constructed a Markov model with states representing diabetes, CHD, stroke, colon cancer and breast cancer to predict costs and QALYs in cohorts aged 30, 40 and 50. Physical exercise was compared to no intervention. Reduced risks associated with physical exercise, cost of diseases and loss of quality of life were obtained from published literature. In low risk persons aged 30 (with a BMI of 26, cholesterol 190 mg/dl and systolic blood pressure of 120 mmHg), controlled and maintained physical exercise costing NIS 2,625 a year along with a subscription to a fitness centre would result in net societal costs of NIS 83,993 for a gain of 1.15 QALYs, giving a cost per QALY of NIS 73,038. This cost per QALY would fall to NIS 49,073 and NIS 12,327 in 40- and 50-year-olds respectively. The intervention would be cost-saving if the annual intervention cost were to fall below NIS 425, NIS 1,040 and NIS 2,205 in 30-, 40- and 50-year-olds, respectively. We did not include results from this study in Table 3 since recruitment costs seem to have been omitted from the model and no intervention to increase physical activity was explicitly defined along with its costs and efficacy rates. The article merely used a wide range of costs ranging from zero to NIS 2,625 per year.

Similarly, we excluded a study by Hatziandreu (Hatziandreu et al., 1988) on GP counseling for "coercive jogging" (where the 35% who did not like jogging continued with the program). They reported a net societal cost per QALY of NIS 93,032 based on QALY gains of 0.53 per participant. The study estimated via a model the QALY and treatment costs averted due to jogging. It also

added in the costs of exercise equipment and the costs of counseling the person to jog as overheads. It thus investigated two scenarios: the first where all persons would jog, and the other where the 65% who liked jogging would voluntarily do so. The study was based on an over-optimistic assumption of 100% (or 65% in the voluntary case) compliance, which not based on any observed study. We estimate that if only 20% decided to jog, costs per QALY would be around NIS 100,000, due to the higher recruitment cost overhead per participant.

## **Cost-Effective and Non-Cost-Effective Interventions (Table 4)**

### ***A. Cost-Effective Studies***

Six of the eight studies that were identified as being cost-effective were part of Roux's meta-study (Roux et al., 2008) described previously:

1. A social support study (Lombard et al., 1995): After an initial training session involving distribution of walking maps and handouts on strategies and support (walking partner or walking group) for starting and maintaining a walking program, the frequency and duration of phone calls were varied to prompt participants to walk. An average of 0.026 QALYs were gained at a cost of NIS 2,754 per participant, giving a cost per QALY of NIS 105,907.
2. An enhanced access study (Linegar et al., 1991): This provided exposure to an environment that emphasized and supported a more active lifestyle (bike paths, extended fitness facility hours, opening of a new fitness center, cycling clubs, marked running courses, organized athletic events). An average of 0.102 QALYs were gained at a cost of NIS 11,262 per participant, giving a cost per QALY of NIS 110,410.
3. Individually adapted health behavior (Jeffery et al., 1998): This used personal trainers, standard behavior-therapy sessions, financial incentives, and phone calls to participants to increase physical activity. An average of 0.064 QALYs were gained at a cost of NIS 7,367 per participant, giving a cost per QALY of NIS 115,115.
4. A second social support study (Kriska et al., 1986): This utilized organized walking groups, social gatherings, phone calls, home visits, and a newsletter to enhance exercise compliance and promote physical activity. An average of 0.031 QALYs were gained at a cost of NIS 4,761 per participant, giving a cost per QALY of NIS 153,573.
5. Individually-adapted health behavior (Knowler et al., 2002): This incorporated intensive lifestyle modification programs for adults at high risk of developing type-2 diabetes. The program involved exercise testing, written information, and individual counseling sessions; a 16-lesson curriculum covering diet, exercise and behavior modification; individual and group exercise sessions; and in-person visits and phone calls to participants. An average of 0.058 QALYs were gained at a cost of NIS 10,523 per participant, giving a cost per QALY of NIS 181,434.
6. The Stanford Five-City Project (Young et al., 1996): This was a 6-year, integrated, community-wide, multi-factorial health education intervention for improving physical activity. The campaign used print materials, radio, TV, seminars, community walking events, worksite- and school-based programs. An average of 0.014 QALYs were gained at a cost of NIS 3,713 NIS per participant, giving a cost per QALY of NIS 265,192.

Another project involved mailing screening questionnaires to all patients aged 60+ on the GP patient list. Inactive patients were invited to attend a series of counseling sessions with an exercise physiologist at their local general practice. Patients were screened opportunistically when visiting their general practice (Cobiac et al., 2009; Halbert et al., 1999; Halbert et al., 2000). The program cost was NIS 768 per participant, and saved NIS 214 in averted treatment costs. The additional average QALY gain of 0.0031 per participant was achieved at a net cost of NIS 554 per participant, giving a cost-utility ratio of NIS 176,842 per QALY (Cobiac et al., 2009).

A UK parallel-group, randomized controlled trial (Isaacs et al., 2007) of individuals aged 40–74 (not currently physically active but with at least one cardiovascular risk factor) consisted of three arms with the primary comparison conducted at 6 months. The 943 patients were randomized (by GP referral) to one of the following three arms: a 10-week program of supervised exercise classes, spending two to three times a week in a local leisure centre; a 10-week instructor-led walking program conducted 2–3 times a week; and an advice-only control group, which received tailored advice and information on physical activity including information on local exercise facilities. The net increase in the proportion of persons achieving at least 150 minutes per week of at least moderate activity was 13.8% in the leisure center group, 11.1% in the walking group and 7.5% in the advice-only group. All groups attained significant reductions in blood pressure, sustained improvements in cardio-respiratory fitness and small reductions in total and low-density lipoprotein cholesterol. All three groups showed improvements in anxiety and well-being scores at 6 months, with the leisure center and walking groups maintaining this improvement at 1 year. The leisure centre group incurred a net societal cost of NIS 2,033 per person compared to controls, but gained 0.016 QALYs at a cost of NIS 127,086 per QALY.

### ***B. Non-Cost-Effective Studies***

GP referrals for community-based walking were not found to be cost-effective (with a one-year time horizon) compared with GP exercise advice alone, costing NIS 308,836 per QALY (based on NIS 1,235 costs in order to gain 0.004 QALYs) exceeded the thrice GNP per capita guideline (Isaacs et al., 2007).

**Table 4: Cost-Effective and Non-Cost-Effective Primary Prevention Interventions versus Usual Care (ranked by Net Societal Cost per QALY) (NIS 2008)**

		QALYs Gained	Gross Intervention Cost (a)	Gross Societal Cost (b)	Net Cost (c)	Net Societal Cost (d)	Gross Cost per QALY	Gross Societal Cost per QALY	Net Cost per QALY	Net Societal Cost per QALY
<b>Cost- Effective</b>										
Roux	Social support	0.026	–	–	–	2,754(e)	–	–	–	105,907
Roux	Enhanced access	0.102	–	–	–	11,262(e)	–	–	–	110,410
Roux	Individually adapted health behavior	0.064	–	–	–	7,367(e)	–	–	–	115,115
Isaacs	GP referral for leisure center exercise (f)	0.016	1,204	1,900	1,338	2,033(g)	75,266	118,758	83,595	127,086
Roux	Social support	0.031	–	–	–	4,761(e)	–	–	–	153,573
Cobiac/ Halbert	GP referral to exercise Physiologist vs. null	0.0031	417	768	301	554(e)	133,028	245,054	96,000	176,842
Roux	Individually adapted health behavior	0.058	–	–	–	10,523(e)	–	–	–	181,434
Roux	Community wide campaign	0.014	–	–	–	3,713(e)	–	–	–	265,192
<b>Non Cost-Effective</b>										
Isaacs	GP referral for community based walking (f)	0.004	597	1,195	637	1,235(g)	149,219	298,698	159,357	308,836

(a) Intervention cost alone

(b) Intervention cost including productivity and possibly travel costs

(c) Intervention cost less treatment savings

(d) Gross societal costs less treatment savings

(e) Lifetime time horizon

(f) Compared with GP exercise advice

(g) One-year time horizon

## 5. Discussion

Lack of physical exercise is a serious and expensive risk factor for many chronic diseases. In 2008, approximately NIS 1.5 billion (ranging from NIS 1.0 billion to NIS 2.2 billion) in direct health costs were found to be attributable to physical inactivity in Israel, representing an estimated 0.21% (range 0.14% to 0.31%) of Israel's GNP. Indirect costs were unavailable. Had they been included they would increase the percentage of GNP attributable to physical inactivity.

Primary preventive interventions based on the Green Prescription (Elley et al., 2003; Elley et al., 2004; Dalziel et al., 2006) and the Step Test Exercise Prescription and patient counseling (STEP) (Petrella et al., 2003) as well as community programs to increase pedometer use (Cobiac et al., 2009; Eakin et al., 2007; Bravata et al., 2007; Brown et al. 2006), and joint mass media-based/community activity campaigns (Cobiac et al., 2009; Bauman et al., 2001; NSW Health, 2000) were found to be cost-saving (Table 2). Transport programs to encourage walking, paid media advertisements, public relations events with worksite, community-based and local activities, exposure to dedicated websites (Roux et al., 2008; Reger et al., 2002), supervised group exercise classes (Munro et al., 2004) and GP-delivered exercise advice (Lindgren, 2003) were found to be very cost-effective in an Israeli healthcare setting (Table 3). Eight more interventions were found to be cost-effective.

In addition, many of the tertiary interventions for patients with such diseases as coronary artery disease, diabetes mellitus, and osteoarthritis were either cost-saving or very cost-effective (Appendices II, III and IV).

These findings corroborate the cost-savings reported in other studies aiming to increase physical activity in elderly and working populations. Elderly participants in a community-based exercise program in the USA, had a 5.9% reduction in healthcare costs overall, and a 20.7% reduction when data from persons who actually attended the exercise program at least once a week were analyzed (Ackermann et al., 2003). A one-year intervention for frail older adults living in the community was carried out in Seattle, Washington in 1997. It focused on physical activity and chronic illness self-management. Intervention costs were NIS 1,409 per participant. During the study year, the program saved NIS 9,803 per participant in reduced hospital utilization costs (Leveille et al., 1998). Nursing home residents in the USA who participated in a Tai Chi exercise program had one fewer fall every two years and a third less chance of suffering a hip fracture. The program had a direct cost saving of around NIS 34 per participant (Wilson and Datta, 2001).

A Californian back-injury prevention program covering 4,398 county employees (Leiyu, 1993), which included a fitness module that emphasized participation in regular physical exercise was implemented over 12 months and followed up for one year afterwards. It cost NIS 610,000, but saved over NIS 1,727,000 (approximately 55% from decreased absenteeism and 40% from lower medical costs) in the post-treatment year.

The cost-utility ratios of all the interventions could be viewed as being upwardly biased, since no source study undertook the – admittedly difficult – estimation of the reduction of caregivers' burden expressed in terms of reduced costs and increased quality of life.

Consequently, policymakers have a variety of economically robust interventions from which to choose. It is unlikely that any one single intervention could totally reduce the considerable population burden of disease stemming from lack of physical exercise. A multi-faceted approach is required to achieve this, one that combines the various interventions that have been identified above, naturally beginning with those found to be cost-saving. Of course, the programs would need modifications in order to fit in with the specific characteristics of different sub-populations (e.g., the ultra-Orthodox, Bedouin, etc.) existing in Israeli society. We are unaware of existing studies that have assessed the efficacy or cost-efficacy of multiple interventions aimed at a single person.

Trials have shown some evidence of potentially effective strategies to increase physical activity in children (van Sluijs, 2007). Strong controlled-trial evidence supports school-based interventions with the involvement of the family or community and multi-component interventions to increase physical activity in adolescents (van Sluijs, 2007). Costs of campaigns to promote adolescent physical activity (Peterson et al., 2008) have been reported. However, health outcome improvements (i.e., reduction in the incidence of diabetes mellitus) have not yet been assessed. Therefore, these data do not allow generation of data on QALYs saved and hence CUAs. Consequently, school-based interventions are not covered in this paper.

Our calculations are based on the assumption that because the vast majority of Israel's population is covered by National Health Insurance, and because Israel's small size encourages access to healthcare, interventions will be accessible to 100% of the Israeli population. However, until the interventions are actually offered, any estimates of adherence are likely to be inaccurate. In any case, even if the assumed adherence rates change somewhat, this would not significantly impact the cost-utility calculation, as both the numerator (cost) and the denominator (QALYs saved) would change by similar proportions (excluding the costs related to setting-up, training and advertising).

Due to cultural and health system differences, it would be presumptuous to assume that effectiveness measures from a single behavioral trial (as opposed to pharmaceutical trials) conducted abroad would be immediately transferable to the Israeli health system. Therefore, we cannot automatically use international cost-utility data to identify the two or three programs that should be adopted in Israel. Instead, the data can be used to identify groups of potential programs that are likely to be cost-saving or very cost-effective. These should be explored and evaluated locally.

It is clearly in the interest of the four Israeli health plans to provide interventions that are cost-saving. However, for historical and economic reasons, the health plans expect the government to fund such interventions from the basket of health services, claiming that treatment savings from reduced morbidity should not be incorporated into the funding scheme. Because the savings from today's interventions accrue only years into the future, perhaps a low- or zero-interest loan mechanism could be set up, with the treasury financing these essential programs now in return for payments from gains accrued by the health plans in the future.

In searching for funding, each of the recommended interventions presented above to reduce the burden of disease due to sedentariness will need to compete against the many interventions available for the prevention and treatment of the myriad of diseases and risk factors extant in the population. The cost-utility ratios reported in this study provide important objective evidence to aid policymakers make such decisions based on objective evidence processed in a uniform fashion.

Adopting a variety of the many proven cost-saving or very cost-effective interventions identified in this paper will serve to help Israel meet the Healthy Israel 2020 target values of decreasing sedentariness by 9.3 percentage points (i.e., reducing lack of physical activity from 71.3% to 62%). This should save the health services alone nearly NIS 197 million (range: NIS 133 million to NIS 290 million) as well as save considerable losses of productivity due to absenteeism and lower productivity.

These results are corroborated by other studies in the literature. A model based on the U.S. population aged 35–74 assessed the cost-benefit of engaging in a regular walking program to prevent coronary heart disease (CHD) (Jones and Eaton, 1994). Assuming a relative risk of 1.9 for CHD associated with sedentary behavior, approximately \$5.6 billion (at USA 1991 price levels) would be saved annually if 10% of adults began such a program. Based on Israeli demographic, wage and health-cost data for 2008, this translates into a total savings of around NIS 465 million in Israel. Of these, approximately NIS 318 million will be saved by the health services. These savings are adjusted for losses due to walking-induced injuries, but only take into account the beneficial aspect of walking vis-à-vis cardiovascular disease, and do not include its beneficial effects on other diseases.

Even greater savings were estimated to result from an approach that combined lifestyle interventions including encouraging physical activity. This took place in the context of an Israeli community-based study in the city of Ashkelon, which aimed for non-pharmacologic control of hypertension. The intervention was based on increasing physical exercise along with improved nutrition, smoking cessation and reducing stress using relaxation techniques. The discounted (at 3% per annum using a ten-year time horizon) program costs of NIS 3,300 per participant, were exceeded by the NIS 9,700 savings from the reduction in medication use alone (Ginsberg et al., 1990). Administration of the project to individuals by physician-nurse teams was found to be more cost-beneficial than that delivered to groups by a team of paramedical professionals consisting of a psychologist, nutritionist and physical activity instructor (Ginsberg et al., 1993). If such a program were extended nationally, the savings (NIS 1,959 million) from reduced medical treatment costs would exceed the NIS 1,202 million program costs by NIS 757 million. In addition, it is estimated that 2,242 lives, 35,117 life years or 32,369 QALYs, would be saved by this cost-saving intervention (Yosefy et al., 2007).

Finally, from a human standpoint, increasing the level of physical activity of the population has the potential to enhance the quality of life of the population as a whole. This is particularly relevant in those with multiple risk factors or diseases. .

This report completes the trilogy of papers aimed at evaluating programs to reducing obesity, tobacco use and physical inactivity in Israel. The current challenge is now to implement the prioritized interventions by channeling dedicated resources to health promotion and disease prevention.

## Bibliography

- Ackermann, R.T.; Cheadle, A.; Sandhu, N.; Madsen, L.; Wagner, E.H.; and LoGerfo, J.P. 2003. "Community Exercise Program Use and Changes in Healthcare Costs for Older Adults." *American Journal of Preventive Medicine* 25(3):232-237.
- Annemans, L.; Lamotte, M.; Clarys, P.; and Van den Abeele, E. 2007 "Health Economic Evaluation of Controlled and Maintained Physical Exercise in the Prevention of Cardiovascular and Other Prosperity Diseases." *European Journal of Cardiovascular Prevention and Rehabilitation* 14(6):815-824.
- Avenell, A.; Broom, J.; Brown, T.J; Poobalan A.; Aucott L.; Steams S.C.; and Smith W.C. 2004. "Systematic Review of the Long-Term Effects and Economic Consequences of Treatments for Obesity and Implications for Health Improvement." *Health Technology Assessment* 8(21):1-182. Review.
- Bauman, A.E.; Bellew, B.; Owen, N.; and Vita P. 2001. "Impact of an Australian Mass Media Campaign Targeting Physical Activity in 1998." *American Journal of Preventive Medicine* 21:41-47.
- Bauman, A.; Bull, F.; Tien, C.; Craig, C.I.; Ainsworth, B.E.; Sallis, J.F.; Bowles, H.R.; Hagstromer, M.; Sjostrom, M.; Pratt, M. and the IPS Group. 2009. "The International Prevalence Study on Physical Activity: Results from 20 Countries." *International Journal of Behavioral Nutrition and Physical Activity* 6:21. doi: 10.1186/1479-5868-6-21.
- Birmingham Rehabilitation Uptake Maximisation Study (BRUM). 2007. "Home-Based Compared with Hospital-Based Cardiac Rehabilitation in a Multi-Ethnic Population: Cost-Effectiveness and Patient Adherence." *Health Technology Assessment* 11(35):1-118.
- Bravata, D.M.; Smith-Spangler, C.; Sundaram, V.; Gienger, A.L.; Lin N.; Lewis R.; Stave Q.; Olkin I.; Sirard J.R. 2007. "Using Pedometers to Increase Physical Activity and Improve Health – A Systematic Review." *Journal of the American Medical Association* 298:2296-2304.
- Brown, A.D. and Garber, A.M. 1988. "Cost Effectiveness of Coronary Heart Disease Prevention Strategies in Adults." *Pharmacoeconomics* 14(1):27-48.
- Brown, W.; Mummery, W.; Eakin, E.; and Schofield, G. 2006. "10,000 Steps Rockhampton: Evaluation of a Whole Community Approach to Improving Population Levels of Physical Activity." *Journal of Physical Activity Health* 3:1-15.
- Central Bureau of Statistics and the Department of Computing and Information, Ministry of Health. 2006. *National Health Survey* (in the framework of the WHO National Mental Health Survey 2003-2004).
- Chen, I-J.; Chou, C-L.; Yu, S.; and Cheng, S-P. 2008. "Health Services Utilization and Cost Utility Analysis of a Walking Program for Residential Community Elderly." *Nursing Economics* 6(4):263-269.

- Clark, A.M.; Hartling, L.; Vandermeer, B.; and McAlister, F.A. 2005. "Meta-Analysis: Secondary Prevention Programs for Patients with Coronary Artery Disease." *Annals of Internal Medicine* 143:659-672.
- Cobiac, L.J.; Vos, T.; and Barendregt, J.J. 2009. "Cost-Effectiveness of Interventions to Promote Physical Activity: a Modelling Study." *PLoS Med* 6(7): e10000110.doi: 10.1371/journal.pmed.10000110.
- Cordain, L.; Gotshall, R.W.; and Eaton S.B. 1998. "Physical Activity, Energy Expenditure and Fitness: an Evolutionary Perspective." *International Journal of Sports Medicine* 19:328-335.
- Da Costa, D.; Abrahamowicz, M.; Lowensteyn, I.; Bermatsky S.; Drista M.; Fitzcharles M.A.; Dobkin P.L. 2005. "A Randomized Clinical Trial of an Individualized Home-Based Exercise Programme for Women with Fibromyalgia." *Rheumatology* 44:1422-1427.
- Dalziel, K. and Segal, L. 2007. "Time to Give Nutrition Interventions a Higher Profile: Cost-Effectiveness of 10 Nutrition Interventions." *Health Promotion International* 22(4):271-283. Epub 2007 Oct 4. Review.
- Dalziel, K.; Segal, L.; and Elley, C.R. 2006. "Cost Utility Analysis of Physical Activity Counseling in General Practice." *Australian and New Zealand Journal of Public Health* 30:57-63.
- de Vries, S.O.; Visser, K.; de Vries, J.A.; Wong, J.B.; Donaldson, M.C.; and Hunink, M.G.M. 2002. "Intermittent Claudication: Cost-Effectiveness of Revascularization versus Exercise Therapy." *Radiology* 222:25-36.
- Diabetes Prevention Research Group. 2003. "Within-Trial Cost-effectiveness of Lifestyle Intervention or Metformin for the Primary Prevention of Type 2 Diabetes." *Diabetes Care* 26(9):2518-2523.
- Dubbert, P.M.; Cooper K.M.; Kirchner K.A.; Meydrech E.F.; and Billbrew D. 2002. "Effects of Nurse Counselling on Walking for Exercise in Elderly Primary Care Patients." *The Journals of Gerontology, Series A, Biological Sciences and Medical Sciences* 57:M733-740.
- Eakin, E.G.; Mummery, K.; Reeves, M.M.; Lawler, S.P.; Schofield, G.; Marshall A.J.; Brown W.J. 2007. "Correlates of Pedometer Use: Results from a Community Based Physical Activity Intervention Trial (10,000 Steps Rockhampton)." *International Journal of Behavioral Nutrition and Physical Activity* 4:31.
- Ebrahim, S. and Smith, G.D. 1997. "Systematic Review of Randomized Controlled Trials of Multiple Risk Factor Interventions for Preventing Coronary Heart Disease." *British Medical Journal* 314:1666-1674.
- Eddy, D.M.; Schlessinger, L.; and Kahn, R. 2005. "Clinical Outcomes and Cost-Effectiveness of Strategies for Managing People at High-Risk for Diabetes." *Annals of Internal Medicine* 143:251-264.

Elley, C.R.; Kerse, N.; Arroll, B.; and Robinson, E. 2003 "Effectiveness of Counseling Patients on Physical Activity in General Practice: Cluster Randomized Controlled Trial." *British Medical Journal* 326:793-96.

Elley, R.; Kerse, N.; Arroll, B.; Swinburn, B.; Ashton, T.; and Robinson, E. 2004 "Cost-Effectiveness of Physical Activity Counseling in General Practice." *Journal of the New Zealand Medical Association* 117:1207.

Epel, O.B. and Ziva Regev M. 2000. "Quality and Correlates of Physical Activity Counseling by Health Care Providers in Israel." *Preventive Medicine* 31:618-626.

European Observatory on Health Systems and Policies. Health System Profiles.  
[http://www.euro.who.int/observatory/Hits/20020525\\_1](http://www.euro.who.int/observatory/Hits/20020525_1) Accessed March 4, 2009.

Finkelstein, E.A.; Troped, P.J.; Will, J.C.; and Palombo, R. 2002. "Cost-Effectiveness of a Cardiovascular Disease Risk Reduction Program aimed at Financially Vulnerable Women: the Massachusetts WISEWOMAN Project." *Journal of Women's Health & Gender-Based Medicine* 11(6):519-526.

Georgiou, D.; Chen, Y.; and Appadoo, S. 2001. "Cost-Effectiveness Analysis of Long-Term Moderate Exercise Training In Chronic Heart Failure." *American Journal of Cardiology* 87:984-988.

Ginsberg, G.M.; Viskoper, R.J.; Fuchs, Z.; Drexler, I.; Lubin, F.; Berlin, S.; Nitzan, H.; Zulty, L.; Chitrit, A.; Bregman, L.; and Modan, M. 1993 "A Partial Cost-Benefit Analysis of Two Different Modes of Non-Pharmacological Control of Hypertension in the Community." *Journal of Human Hypertension* 7:593-597.

Ginsberg, G.M.; Viskoper, R.J.; Oren, S.; Bregman, L.; Mishal, Y.; and Sherf, S. 1990. "Resource Savings from Non-Pharmacological Control of Hypertension." *Journal of Human Hypertension* 4:375-378.

Gusi, N. and Tomas-Carus, P. 2008. "Cost-Utility of an 8-Month Aquatic Training for Women with Fibromyalgia: a Randomized Controlled Trial." *Arthritis Research & Therapy* 10:R24 (doi:10.1186/ar2377).

Gusi, N.; Reyes, M.C.; Gonzalez-Guerrero, J.L.; Herrera, E.; and Garcia, J.M. 2008. "Cost-Utility of a Walking Programme for Moderately Depressed, Obese, or Overweight Elderly Women in Primary Care: A Randomized Controlled Trial." *BioMedCentral Public Health* 8:231. doi:10.1186/1471-2458-8-231.

Hagberg L. 2007. *Cost-Effectiveness of the Promotion of Physical Activity in Health Care*. Umea University Medical Dissertations, New series No. 1085 ISSN 0546-6612. ISBN 978-91-7264-259-1. Umea University, Sweden.

- Hagberg, L.A. and Lindholm, L. 2006. "Cost-Effectiveness of Healthcare-Based Interventions Aimed at Improving Physical Activity." *Scandinavian Journal of Public Health* 34:641-53.
- Halbert, J.A.; Silagy, C.A.; Finucane, P.; Withers, R.T.; and Hamdorf, P.A. 1999. "Recruitment of Older Adults for a Randomized Controlled Trial of Exercise Advice in a General Practice Setting." *Journal of the American Geriatrics Society* 47:84-87.
- Halbert, J.A.; Silagy, C.A.; Finucane, P.; Withers, R.T.; and Hamdorf PA. 2000. "Physical Activity and Cardiovascular Risk Factors: Effect of Advice from an Exercise Specialist in Australian General Practice." *Medical Journal of Australia* 173:84-87.
- Hall, D.E. 2006. "Religious Attendance: More Cost-Effective than Lipitor?" *Journal of the American Board of Family Medicine* 19:103-109.
- Handley, M.; Shumway, M.; and Schillinger, D. 2008. "Cost-Effectiveness of Automated Telephone Self-Management Support with Nurse Care Management among Patients with Diabetes." *Annals of Family Medicine* 6:512-518.
- Harada, A.; Kawakubo, K.; Lee, J.S.; Fukuta T.; Kobayashi Y. 2001. "Cost and Effectiveness of Exercise Therapy for Patients with Essential Hypertension." *Nippon Koshu Eisei Zasshi (Japanese Journal of Public Health)* 48:753-763 (Japanese).
- Harland, J.; White, M.; Drinkwater, C.; Chinn, D.; Farr, L.; and Howel, D. 1999. "The Newcastle Exercise Project: a Randomized Controlled Trial of Methods to Promote Physical Activity in Primary Care." *British Medical Journal* 319:828-832.
- Haskell, W.L.; Lee, I-M.; Pate, R.R.; Powell K.E; Blair S.N; Franklin B.A; Macera C.A; Heath G.W; Thompson P.D.; Bauman, A.; American College of Sports Medicine; and the American Heart Association. 2007. "Physical Activity and Public Health. Updated Recommendations for Adults from the American College of Sports Medicine and American Heart Association." *Circulation* 116:1081-1093.
- Hatziandreu, E.I.; Koplan, J.P.; Weinstein, M.C.; Capersen, C.J.; and Warner, K.E. 1988 "A Cost-Effectiveness Analysis of Exercise as a Health Promotion Activity." *American Journal of Public Health* 78:1417-1421.
- Isaacs, A.J.; Critchley, J.A.; See Tai, S.; Buckingham, K.; Westley, D.; Harridge, S.D.; Smith C.; Gottlieb J.M. 2007. "Exercise Evaluation Randomized Trial (EXERT): a Randomized Trial Comparing GP Referral for Leisure Center-Based Exercise, Community-Based Walking and Advice Only." *Health Technology Assessment* 11(10) 1-165.
- Jeffery, R.W.; Wing, R.R.; Thorson, C.; and Burton L.R. 1998. "Use of Personal Trainers and Financial Incentives to Increase Exercise in a Behavioral Weight-Loss Program." *Journal of Consulting and Clinical Psychology* 66:777-785.
- Jones, T.F. and Eaton, C.B. 1994. "Cost-Benefit Analysis of Walking to Prevent Coronary Heart Disease." *Archives of Family Medicine* 3:703-710.

- Kahn, E.B.; Ramsay, L.T.; Brownson, R.C. 2002 "The Effectiveness of Interventions to Increase Physical Activity. A Systematic Review." *American Journal of Preventive Medicine* 22(4S):73-107.
- Katzmarzyk, P.T.; Gledhill, N.; and Sephardi, R.J. 2000. "The Economic Burden of Physical Inactivity in Canada." *Canadian Medical Association Journal* 163(11):1435-1440.
- King, A.C. 1999. "Environmental and Policy Approaches to the Promotion of Physical Activity." In Rippe J. (ed.) *Lifestyle Medicine*. Blackwell Science, Norwalk (CT).
- Knowler, W.C.; Barrett-Connor, E.; Fowler, S.E; Hamman R.F.; Lachin J.M.; Walker E.A.; Nathan D.M.; Diabetes Prevention Program Research Group. 2002. "Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin." *New England Journal of Medicine* 346:393-403.
- Kosma, M.; Cardinal, B.J.; and McCubbin, J.A. 2005. "Longitudinal Effects of a Web-based Physical Activity Motivational Program among Adults with Physical Disabilities." *Research Quarterly for Exercise and Sport* 86:A116.
- Kriska, A.M.; Bayles, C.; Cauley, J.A.; LaPorte, R.E.; Sandler, R.B.; and Pambianco, G. 1986. "A Randomized Exercise Trial in Older Women: Increased Activity over Two Years and the Factors Associated with Compliance." *Medicine & Science in Sports & Exercise* 18:555-562.
- Lamb, S.E.; Bartlett, H.P.; Ashley, A.; and Bird, W. 2002. "Can Lay-Led Walking Programmes Increase Physical Activity in Middle Aged Adults? a Randomized Controlled Trial." *Journal of Epidemiology and Community Health* 56:246-252.
- Lee, I.M. and Skerrett, P.J. 2001. "Physical Activity and All-Cause Mortality: What is the Dose-Response Relation?" *Medicine and Science in Sports and Exercise* 33(6 Suppl):S459-S471.
- Leiyu, A. 1993 "A Cost-Benefit Analysis of a California County's Back Injury Prevention Program." *Public Health Reports* 108(2):204-211.
- Leveille, S.G.; Wagner, E.H.; Davis, C.; Grothaus, L.; Wallace, J.; Lo Gerfo, M.; and Kent, D. 1998. "Preventing Disability and Managing Chronic Illness in Frail Older Adults: a Randomized Trial of a Community-Based Partnership with Primary Care." *Journal of the American Geriatrics Society* 46(10):1191-1198.
- Levin, L.A.; Perk, J.; and Hedback B. 1991. "Cardiac Rehabilitation – a Cost Analysis." *Journal of Internal Medicine* 230:427-434.
- Lindgren, P.; Fahlstadius, P.; Hellenius, M-L.; Jonsson, B.; and de Faire, U. 2003. "Cost-Effectiveness of Primary Prevention of Coronary Heart Disease through Risk Factor Intervention in 60-year-Old Men from the County of Stockholm – a Stochastic Model of Exercise and Dietary Advice." *Preventive Medicine* 36:403-409.

- Lineger, J.M.; Chesson, C.V. 2<sup>nd</sup>; and Nice, D.S. 1991. "Physical Fitness Gains Following Simple Environmental Change." *American Journal of Preventive Medicine* 7:298-510.
- Lombard, D.N.; Lombard, T.N.; and Winett, R.A. 1995. "Walking to Meet Health Guidelines: The Effect of Prompting Frequency and Prompt Structure." *Health Psychology* 14:164-170.
- Lowensteyn, I.; Coupal, L.; Zowall, H.; and Grover S.A. 2000. "The Cost-Effectiveness of Exercise Training for Primary and Secondary Prevention of Cardiovascular Disease." *Journal of Cardiopulmonary Rehabilitation* 20:147-155.
- McCarthy, C.J.; Mills, P.M.; Pullen, R.; Richardson, G.; Hawkins, N.; Roberts, C.R.; Silman, A.J.; Oldham J.A. 2004. "Supplementation of a Home-based Exercise Program with Class-based Programme for People with Osteoarthritis of the Knees: a Randomized Controlled Trial and Health Economic Analysis." *Health Technology Assessment* 8 (46) 1-61. Review.
- Ministry of Health. April 2009. *National Strategies and Interventions for Prevention. Part 3: Physical Activity for Health Promotion. Sub-Committee for Physical Activity, Committee for Health Behaviors*. Healthy Israel 2020 Initiative, Ministry of Health, Jerusalem (Hebrew).
- Munro, J.; Brazier, J.; Davey, R.; and Nicholl, J. 1997. "Physical Activity for the Over-65s: Could it be a Cost-Effective Exercise for the NHS?" *Journal of Public Health Medicine* 19(4):397-402.
- Munro, J.F.; Nicholl, J.P.; Brazier, J.E.; Davey, R.; and Cochrane, T. 2004. "Cost Effectiveness of a Community Based Exercise Programme in Over 65 Year Olds: Cluster Randomized Trial." *Journal of Epidemiology and Community Health* 58:1004-1010.
- Napolitano, M.A.; Fotheringham, M.; Tate, D.; Sciamanna, C.; Leslie, E.; Owen, N.; Bauman, A.; Marcus, B. 2003. "Evaluation of an Internet-based Physical Activity Intervention: a Preliminary Investigation." *Annals of Behavioral Medicine* 25:92-99.
- National Institute of Public Health in Sweden. 1999. *Sjukdomsborden I Sverige* (The Burden of Disease in Sweden). Stockholm.
- Nelson M.E.; Rejeski, J.; Blair, S.N.; Duncan, P.W.; Judge, J.O.; King, A.C.; Macera, C.A.; Castaneda-Sceppa, C.; American College of Sports Medicine; American Heart Association. 2007. "Physical Activity and Public Health in Older Adults. Recommendation from the American College of Sports Medicine and the American Heart Association." *Circulation* 116:1094-1105. Epub 2007, Aug 1.
- New South Wales Department of Health. 2000. *NSW Health. Public Education Campaign to Promote Physical Activity among Older People: NSW Evaluation Report*.
- NHS Information Center. 2008. *Health Survey for England 2006: CVD and Risk Factors Adults, Obesity and Risk Factors Children*. Publication date January 31, 2008.  
<http://www.ic.nhs.uk/pubs/hse06cvd>. Accessed June 12, 2011

NICE. 2006. *Modeling the Cost Effectiveness of Physical Activity Interventions*. Matrix Research and Consultancy. January 20, 2006.

Oguma, Y.; Sesso, H.; Paffenbarger, R. Jr.; and Lee, I.M. 2002. "Physical Activity and All Cause Mortality in Women: a Review of the Evidence." *British Journal of Sports Medicine* 36:162-72. Review.

Oldridge, N.; Furlong, W.; Feeny, D.; Torrance, G.; Guyatt, G.; Crowe, J.; Jones, N. 1993. "Economic Evaluation of Cardiac Rehabilitation Soon after Acute Myocardial Infarction." *American Journal of Cardiology* 72:154-161.

Peterson, M.; Chandlee, M.; and Abraham, A. 2008. "Cost-Effectiveness Analysis of a Statewide Media Campaign to Promote Adolescent Physical Activity." *Health Promotion Practice* 9(4):426-433.

Petrella, R.J.; Koval, J.J.; Cunningham, D.A.; and Paterson, D.H. 2003. "Can Primary Care Doctors Prescribe Exercise to Improve Fitness? The Step Test Exercise Prescription (STEP) Project." *American Journal of Preventive Medicine* 24(4):316-322.

Plotnikoff, R.C.; McCargar, L.J.; Wilson, P.M.; and Loucaides, C.A. 2005. "Efficacy of an e-mail Intervention for the Promotion of Physical Activity and Nutritional Behavior in the Workplace Context." *American Journal of Health Promotion* 19:422-429.

Pritchard, D.A.; Hyndman, J.; and Taba F. 1999 "Nutritional Counseling in General Practice: a Cost-Effectiveness Analysis." *Journal of Epidemiology and Community Health* 53:311-316.

Reger, B.; Cooper, L.; Booth-Butterfield, S.; Smith, H.; Bauman, A.; Wootan, M.; Middlestadt, S.; Marcus, B.; Greer, F. 2002. "Wheeling Walks: a Community Campaign Using Paid Media to Encourage Walking Among Sedentary Older Adults." *Preventive Medicine* 35:285-292.

Robertson, M.C.; Devlin, N.; Gardner, M.M.; and Campbell, A.J. 2001. "Effectiveness and Economic Evaluation of a Nurse Delivered Home Exercise Programme to Prevent Falls. 1: Randomised Controlled Trial." *British Medical Journal* 322:697-701.

Robertson, M.C.; Devlin, N.; Schuffman, P.; Gardner, M.M.; Buchner, D.M.; and Campbell A.J. 2001. "Economic Evaluation of a Community Based Exercise Programme to Prevent Falls." *Journal of Epidemiology and Community Health* 55:600-606.

Robertson, M.C.; Gardner, M.M.; Devlin, N.; McGee, R.; and Campbell, A.J. 2001. "Effectiveness and Economic Evaluation of a Nurse Delivered Home Exercise Programme to Prevent Falls. 2: Controlled Trial in Multiple Centres." *British Medical Journal* 322:701-704.

Roux, L.; Pratt, M.; Tengs, T.O. ; Yore, M.M.; Yanagawa, T.L.; Van Den Bos, J.; Rutt, C.; Brownson, R.C.; Powell, K.E.; Heath, G.; Kohl, H.W. 3rd ; Teutsch, S.; Cawley, J.; Lee, I.M.; West, L.; Buchner, D.M. 2008. "Cost Effectiveness of Community-Based Physical Activity Interventions." *American Journal of Preventive Medicine* 35(6):578-588.

- Segal, L.; Day, S.E.; Chapman, A.B.; and Osborne RH. 2004. "Can We Reduce Disease Burden from Osteoarthritis?" *The Medical Journal of Australia* 180:S11-S17.
- Sevick, M.A.; Dunn, A.L.; Morrow, M.A.; Marcus, B.H.; Chen, G.J.; and Blair, S.N. 2000. "Cost-Effectiveness of Lifestyle and Structured Exercise Interventions in Sedentary Adults. Results of Project ACTIVE." *American Journal of Preventive Medicine* 19(1):1-8.
- Sims, J.; Huang, N.; Pietsh, J.; and Naccarella, L. 2004. "The Victorian Active Script Programme: Promising Signs for General Practitioners, Population Health and the Promotion of Physical Activity." *British Journal of Sports Medicine* 38:19-25.
- Smith, B.J.; Bauman, A.E.; Bull, F.C.; Booth, M.L.; and Harris, M.F. 2000. "Promoting Physical Activity in General Practice: a Controlled Trial of Written Advice and Information Materials." *British Journal of Sports Medicine* 34:262-267.
- Stevens, W.; Hillsdon, M.; Thorogood, M.; and McArdle D. 1998. "Cost-Effectiveness of a Primary Care Based Physical Activity Intervention in 45-74 Year Old Men and Women: a Randomized Controlled Trial." *British Journal of Sports Medicine* 32:236-241.
- Swinburn, B.A.; Walter, L.G.; Arroll, B.; Tilyard, M.W.; and Russell, D.G. 1998. "The Green Prescription Study: a Randomized Controlled Trial of Written Exercise Advice Provided by General Practitioners." *American Journal of Public Health* 88(2):288-291.
- Thune, I. and Furber A-S. 2001. "Physical Activity and Cancer Risk: Dose-response and Cancer, All Sites and Site-specific." *Medicine and Science in Sports and Exercise* 33(6 Suppl):S530-S550.
- Treesak, C.; Kasemsup, V.; Treat-Jacanson, D.; Nyman, J.A.; and Hirsch A.T. 2004. "Cost-Effectiveness of Exercise Training to Improve Claudication Symptoms in Patients with Peripheral Arterial Disease." *Vascular Medicine* 9:279-285.
- U.S. Department of Health and Human Services. 2008 *Physical Activity Guidelines for Americans*. <http://www.health.gov/PAGuidelines/guidelines/summary.aspx> Accessed February 25, 2009.
- U.S. Department of Labor, Bureau of Labor Statistics. Bureau of Labor Statistics Data. Consumer Price Index. <http://data.bls.gov/PDQ/servlet/SurveyOutputServlet>. Accessed Feb 10, 2008.
- UK BEAM Trial Team. 2004. "United Kingdom Back Pain Exercise and Manipulation (UK BEAM) Randomized Trial: Cost Effectiveness of Physical Treatments for Back Pain in Primary Care." *British Medical Journal* 329(7479):1381. Epub 2004 Nov 19.
- van den Hout, W.B.; de Jong, Z.; Munneke, M.; Hazes, J.M.W.; Breedveld, F.C.; Vliet Vlieland, T.P.M. 2005. "Cost-Utility and Cost-Effectiveness Analyses of a Long-Term, High-Intensity Exercise Program Compared with Conventional Physical Therapy in Patients with Rheumatoid Arthritis." *Arthritis & Rheumatism (Arthritis Care & Research)* 53(1):39-47.

- van Sluijs, E.M.F.; McMinn, A.M.; and Griffin, S.J. 2007. "Effectiveness of Interventions to Promote PA in Children and Adolescents: SR of Controlled Trials." *British Medical Journal BMJ* (2007):335:703. Epub doi:10.1136/bmj.39320.843947.BE.
- Wake, M.; Gold, L.; McCallum, Z.; Gerner, B.; and Waters, E. 2008. "Economic Evaluation of a Primary Care Trial to Reduce Weight Gain in Overweight/Obese Children: the LEAP Trial." *Ambulatory Pediatrics* 8(5):336-341. Epub 2008 Aug 20.
- Wang, L.Y.; Gutin, B.; Barbeau, P. Moore, J.B; Hanes, J. Jr.; Johnson, M.H.; Cavnar, M.; Thornburg, J.; and Yin, Z. 2008. "Cost-Effectiveness of a School-Based Obesity Intervention Program." *Journal of School Health* 78(12):619-624. Erratum in: *Journal of School Health*. 2009. 79(2):89.
- Wendel-Vos, G.C.; Schuit, A.J.; Feskens, E.J.; Boshuizen, H.C.; Verschuren, W.M.; Saris, W.H.; and Kromhout, D. 2004. "Physical Activity and Stroke. A Meta-analysis of Observational Data." *International Journal of Epidemiology* 33:787-798.
- WHO Commission on Macroeconomics and Health. 2001. *Macroeconomics and Health: Investing in Health for Economic Development*. Report of the Commission on Macroeconomics and Health. World Health Organization, Geneva.
- WHO. 2002. *World Health Report 2002*. WHO.
- Wilson, C.J. and Datta, S.K. 2001. "Tai Chi for the Prevention of Fractures in a Nursing Home Population: An Economic Analysis." *Journal of Clinical Outcomes Management* 8(3):19-27.
- Woolf, S.H.; Jonas, S.; and Lawrence, R.S. 1996. *Health Promotion and Disease Prevention in Clinical Practice*. Williams & Wilkins, Baltimore, MD.
- Yosefy, C.; Ginsberg, G.; Viskopfer, R.; Dicker D.; and Gavish, D. 2007. "Cost-Utility Analysis of a National Project to Reduce Hypertension in Israel." *Cost Effectiveness and Resource Allocation* 5:16 doi:10.1186/1478-7547-5-16.
- Young, D.R.; Haskell, W.I.; Taylor, C.B.; and Fortmann, S.P. 1996. "Effect of Community Health Education on Physical Activity Knowledge, Attitudes, and Behavior." The Stanford Five-City Project. *American Journal of Epidemiology* 144:264-274.
- Yu, C-M.; Lau, C-P.; Chau, J. McGhee, S.; Kong, S.L.; Cheung, B.M.; and Li, L.S. 2004. "A Short Course of Cardiac Rehabilitation Program is Highly Cost Effective in Improving Long-term Quality of Life in Patients with Recent Myocardial Infarction or Percutaneous Coronary Intervention." *Archives of Physical Medicine and Rehabilitation* 85:1915-1922.

## Appendix I: Tertiary Prevention

Note: Tertiary prevention is defined in this document as providing preventive care to symptomatic patients in an effort to decrease complications or severity of disease (Woolf et al., 1996).

Physical Exercise programs have been shown to be beneficial in the tertiary prevention of many diseases ranging from ischemic heart disease to fibromyalgia. A meta-analysis of 63 randomized trials on 21,295 patients with coronary artery disease (Clark et al., 2005) examined the effects of different types of cardiac tertiary prevention programs. Over a median follow-up time of 12 months, similar beneficial effects were found for programs that included risk factor education or counseling with a structured exercise component (risk ratio 0.88, CI 0.74–0.84) for mortality and 0.62 (CI 0.44–0.87) for myocardial infarction and for programs that included risk factor education or counseling without an exercise component (risk ratio 0.87, CI 0.74–0.84) for mortality and 0.86 (CI 0.72–1.03) for myocardial infarction. Programs that were solely exercise-based had non-significant lower mortality risk (risk ratio 0.72, CI 0.54–0.95) but similar myocardial infarction risk (risk ratio 0.76, CI 0.57–1.01) relative to the other two types of tertiary prevention programs. The authors commented that although these programs may reduce total healthcare costs, published data on the costs of the programs are inadequate to comment conclusively on their cost-effectiveness.

A 12-week individualized home-based exercise program on physical functioning, pain severity and psychological distress for 79 women with fibromyalgia found a significant improvement in functional capacity, especially upper body pain (at 3 and 9 months) following treatment for patients randomized to the exercise group who were more functionally disabled at study entry. Notwithstanding the small size of the study, the authors concluded that home-based exercise, a relatively low-cost treatment modality, has the potential to improve important health outcomes in fibromyalgia (Da Costa et al., 2005).

A rehabilitation program in Sweden consisting of health education and physical training in outpatient groups was given to patients under 65 years old who had suffered a myocardial infarction. As compared to the standard care control group, healthcare cost-savings in the rehabilitation program exceeded program costs by 60%. Rehabilitation patients returned to work earlier and more frequently, resulting in overall (healthcare plus productivity) savings being 17.4 times that of program costs (Levin et al., 1991).

As for primary interventions, some studies did not present their results in a format suitable for cost-utility analysis.

- ◆ Exercise rehabilitation to improve claudicating symptoms in patients with peripheral arterial disease (Treesak et al., 2004) was found to dominate percutaneous transluminal angioplasty (PTA) since patients walked an additional 137 meters at a cost of NIS 226 less per meter gained.
- ◆ Exercise therapy given to Japanese hypertensive outpatients (Harada et al., 2001) reported a cost of 255 NIS per mmHg reduction in systolic blood pressure.

However a number of studies were identified that enabled comparisons to be made according to the cost per QALY gold standard. These are presented in Appendices II, III and IV.

## **Appendix II: Net Cost per QALY of Tertiary Prevention Interventions versus Comparators**

Physical exercise can be an important component of tertiary prevention. The two cost-saving interventions were for cardiac rehabilitation. Hospital-based cardiac rehabilitation (including exercise) only had a slight QALY and cost advantage over home-based rehabilitation (Birmingham Rehabilitation Study, 2007). However when compared with rehabilitation programs based on education without an exercise component, the QALY gains and cost savings were substantial (Yu et al., 2004). The addition of a physiotherapist- class-based exercise component to home exercises only (McCarthy et al., 2004) was found to be very cost-effective (Net Societal Cost per QALY of only NIS 126). Hagberg studied the effects of GP-based structured consultations that counseled patients to exercise combined with an offer of group exercise programs for persons whose illnesses were deemed to be treatable by physical activity (Hagberg, 2007; Hagberg and Lindholm, 2006). He found this combined intervention to be very cost-effective when compared to a control group of persons receiving only low intensity counseling from a GP.

Group and individual diet and physical exercise were found to be cost-effective compared with the use of metformin or placebo for impaired glucose intolerance (Diabetes Prevention Research Group, 2003). The addition of percutaneous transluminal angioplasty (PTA) to exercise programs was also found to be cost-effective for patients with intermittent claudication (de Vries et al., 2002), whereas addition of by-pass surgery and PTA to exercise programs was far from being cost-effective (net societal cost of over NIS 1.6 million per QALY).

**Table II-1 :Tertiary Prevention Interventions versus Comparators (ranked by Net Cost per QALY)**

Study	Intervention (vs. comparator)	Health Problem	QALYS Gained	Net Cost (a)	Net Societal Cost (b)	Net Cost per QALY	Net Societal Cost per QALY
<b>Cost-Saving</b>							
BRUM study	Hospital based Cardiac Rehabilitation vs Home Rehabilitation	AMI or Coronary Revascularization	0.002	-238	95	cs	cs
Yu	Cardiac Rehabilitation- Exercise & education vs education w/out exercise	MI or Percutaneous Coronary Intervention	0.06	- 1,664(c)	na	cs	na
<b>Very Cost-Effective</b>							
McCarthy	Physiotherapist Class based & home exercise vs home exercise	Osteoarthritis of Knees	0.023	-234(d)	3	cs	127
Hagberg	GP structured consultation providing group based exercises vs Low-intensity promotion of PA from GP	Illnesses treatable with PA such as musculoskeletal pain, cardiovascular diseases, diabetes, mental illnesses and obesity.	0.137	1454(e)	1,649	10,616	12,255
<b>Cost-Effective</b>							
Diabetes Prevention Research Group	Group & Individual Dietary Advice & Physical Exercise vs Metformin	Impaired Glucose Tolerance	0.048	300(e)	4,740	6,197	97,795
De Vries	PTA & Exercise vs Exercise	Intermittent claudication	0.090	na	17,825(f)	na	198,054
Diabetes Prevention Research Group	Group & Individual Dietary Advice & Physical Exercise vs Placebo	Impaired glucose tolerance	0.069	9,507	14,874(e)	136,969	214,302
<b>Not Cost-Effective</b>							
De Vries	PTA & By-Pass Surgery & Exercise vs Exercise	Intermittent claudication	0.170	na	275,556	na	1,620,916

cs cost saving

na not available

- (a) Intervention cost less treatment savings
- (b) Net societal costs less treatment savings.
- (c) Two-year time horizon
- (d) One-year time horizon
- (e) Three-year time horizon
- (f) Lifetime time horizon

## Appendix III: Cost-Saving Tertiary Prevention Interventions versus Usual Care

The 4 cost-saving (compared with usual care) interventions for osteoarthritis using aerobic exercise and strength training were home based (at basic and intensive levels), outpatient clinic based and primary care clinic based (Segal et al., 73). Two cost-saving interventions for diabetes were telephone support and nurse management of exercise (Handley et al., 2008), as was a walking program in a residential home for the elderly (Chen et al., 2008).

**Table III-1: Cost-Saving Tertiary Interventions versus Usual Care (ranked by Net Cost Saved)**

Study	Intervention (cf just advice)	Health Problem	QALYS Gained	Gross Intervention Cost (a)	Gross Societal Cost (b)	Net Cost (c)	Net Societal Cost (d)
<b>Cost-Saving</b>							
Segal	Home based intensive exercise/strength training	Osteoarthritis	0.095	5,265	na	-226(f)	na
Handley	Telephone support & nurse management	Diabetes	0.012	2,454	na	-105(e)	na
Segal	Outpatient clinic exercise/strength training	Osteoarthritis	0.074	2,188	na	-94(f)	na
Segal	Primary care clinic exercise/strength training	Osteoarthritis	0.096	1,780	na	-76(f)	na
Segal	Home based basic exercise/strength training	Osteoarthritis	0.022	1,483	na	-64(f)	na
Chen	Walking Program in Residential	Frailty	0.006	247	322	-11(e)	-14

(a) Intervention cost alone

(b) Intervention cost including productivity and possibly travel costs

(c) Intervention cost less treatment savings

(d) Gross societal costs less treatment savings

(e) One-year time horizon

(f) 20-year time horizon

## Appendix IV: Very Cost-Effective and Dominated Tertiary Prevention Interventions versus Usual Care

Exercise classes were found to be a very cost-effective method of treating back pain (UK BEAM, 2004). However, exercise plus manipulation dominated exercise alone in that it provided more QALYs at a lower net cost (UK BEAM, 2004). Other very cost-effective interventions were primary-care-based walking programs for depressed obese patients (Gusi et al., 2008), aquatic training for fibromyalgia (Gusi and Tomas-Carus, 2008), moderate exercise for chronic heart failure (Georgiou et al., 2001), supervised exercise and risk-factor management for acute myocardial infarction patients (Oldridge et al., 1993) and diet and exercise for patients with impaired glucose intolerance (Avenell et al., 2004). On the other hand, for persons with rheumatoid arthritis, long-term high intensity exercise was dominated by usual care, as fewer QALYs were provided at a higher cost (van den Hout et al., 2005).

**Table IV-1: Very-Cost-Effective and Dominated Tertiary Prevention Interventions versus Usual Care (NIS 2008) (Ranked by Net Cost per QALY)**

Study	Intervention (cf just advice)	Health Problem	QALYS Gained	Net Cost (c)	Net Societal Cost (d)	Net Cost per QALY	Net Societal Cost per QALY
<b>Very Cost-Effective</b>							
Gusi	Walking in Primary care	Depressed obese	0.132	198(e)	–		
Georgiou	Moderate exercise training (f,g)	Chronic heart failure	1.139	2,904(h)	13,934	1,500	
Oldridge	Supervised exercise and risk factor management	AMI patients	0.071	1,002(e)	2,905	2,549	12,230
Gusi	Aquatic training	Fibromyalgia	0.131	2,502(e)	4,994	14,109	40,911
UK\$ Beam	Exercise & manipulation	Back pain	0.033	818(e)	–	19,100	38,122
UK\$ Beam	Exercise classes	Back pain	0.017	983(e)	–	24,777	
Avenell	Diet and exercise	Impaired glucose intolerant	0.000	–	–	57,807(i)	
<b>Dominated(j)</b>							
Van de Hout	Long-term high intensity classes	Rheumatoid arthritis	-0.029	2,167(k)	3,030	Dominated	Dominated

(a) Intervention cost alone

(b) Intervention cost including productivity and possibly travel costs

(c) Intervention cost less treatment savings

(d) Gross societal costs less treatment savings

(e) One-year time horizon

(f) Excludes QALY gains from reduced morbidity

(g) Assumes average HALE of 0.626 applied to life years saved

(h) Four-year time horizon

(i) Lifetime time horizon

(j) Provides fewer QALYS at a higher cost

(k) Two-year time horizon

## Appendix V: Glossary of Terms and 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.

**BOD:** Burden of Disease: Can be measured in terms of QALYs lost through morbidity and/or mortality as well as the economic costs of treating a disease.

**CHD:** Coronary heart disease

**CVD:** Cardiovascular disease

**DALY:** Disability-adjusted life year is the unit of measurement of the impact of disease in terms of both time lost to premature death (mortality) and time lived with a disability (morbidity).

**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 that is considered equivalent to the actual number of years spent in a defined imperfect state of health or in a series of defined imperfect states of health.

**HALY:** Health-adjusted life year: An umbrella term for a family of measures, HALY includes disability-adjusted life years (DALYs and quality-adjusted life years (QALYs)). These are population health measures permitting morbidity and mortality to be simultaneously described within a single measure.

**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.

**NICE:** National Institute for Clinical Excellence. NICE is a UK-based independent organization responsible for providing national guidance on promoting good health and preventing and treating ill health.

**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.

**PTA:** Percutaneous transluminal angioplasty

**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.

**STEP:** Step Test Exercise Prescription

**Utility:** A quantitative expression of an individual's preference for, or desirability of, a particular state of health under conditions of uncertainty.

As defined in Berger, M.L.; Binglefors, K.; Hedblom, E.C.; Pashos, C.L.; and Torrance, G.(eds.). 2003. *Health Care Cost, Quality, and Outcomes. ISPOR Book of Terms*; and in Gold, M.R.; Stevenson, D.; Fryback, D.G. 2002. "HALYs and QALYs and DALYs, Oh My: Similarities and Differences in Summary Measures of Population Health." *Annual Review of Public Health* 23:115-34.