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Original article

Modelling the lifetime costs and health effects of lifestyle intervention in the prevention and treatment of obesity in Switzerland

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Summary

Aim: To quantify the lifetime health and economic consequences of preventing and treating obesity with lifestyle intervention in Switzerland.
Methods: A Markov model was developed comparing lifestyle intervention and standard care in overweight and obese people. Changes in weight and cardiovascular risk factors over time were modeled from reduction in body mass index, systolic blood pressure, total cholesterol and high density lipoprotein in three-year active treatment period. A probabilistic sensitivity analysis was performed. Three groups of people were followed in the analysis: overweight, borderline and moderate obese. The cost-effectiveness of interventions was compared using incremental cost-effectiveness ratio.
Results: Lifestyle intervention resulted in increased survival duration and quality of life over lifetime. Compared with standard care, the average incremental cost of lifestyle intervention was lower in borderline and obese and higher in overweight. Lifestyle intervention dominated standard care in borderline female age 35 to 55 years, borderline male age 25 to 60 years, obese female age 45 years and obese male age 55 years.
Conclusion: Our economic analysis suggests that lifestyle intervention is cost-effective in the long-term prevention and treatment of obesity.

Key words: Cost-effectiveness – Lifestyle – Overweight – Prevention – Obesity – Treatment.

Obesity has become one of the most common medical problems due to an explosive increase in the number of people affected by the disease. Obesity is associated with numerous co-morbidities such as cardiovascular disease, diabetes, hypertension, certain cancers and sleep apnea (Poirier 2006). Several different treatments are available for the management of obesity: non-pharmacological interventions (e.g. dietary interventions, physical exercise, lifestyle interventions, etc.), pharmacological interventions (e.g. sibutramine, orlistat, etc.), alternative medicine (e.g. acupuncture, hypnotherapy, etc.) and in the case of morbid obesity, surgical treatments (e.g. gastric bypass, gastroplasty, etc). In the latest years a specific interest is focused on prevention strategies that aim to stop the progression of overweight to obesity and the occurrence of obesity complications (World Health Organization 2000).

The economic burden of obesity is substantial. In Switzerland, obesity related expenditures are estimated to a total CHF 2691 million, or almost 2.3–3.5 % of total health care spending (Schmid 2005). The top five co-morbidities responsible for the increased costs associated with overweight and obesity are hypertension, hypercholesterolemia, diabetes mellitus, stroke and coronary heart disease (Neilson 2005). Thus, the economic costs of obesity represent a sizeable issue for the Swiss health care system. The increasing burden on the budgets of health care providers has resulted in considerable interest in assessing new and existing treatments for their clinical effectiveness and cost-effectiveness. Such an assessment enables decisions to be made on the allocation of limited health care resources while ensuring that any additional cost is justified by the additional benefits (Neumann 2005). Among several treatments available, lifestyle interventions have been documented to lead safely to improvements in metabolic abnormalities such as increased body weight, dyslipidemia, elevated blood pressure and glucose control that are linked to the development of obesity, diabetes, and cardiovascular disease (Pritchett 2005). Lifestyle programs are multi-factorial interventions that are designed for each patient or group of patients according to their risk factor status and include promotion of healthy lifestyle habits, dietary counseling, physical exercise training and behavioral change targets.

The aim of the present study is to develop a decision analytic model to quantify the lifetime health and economic consequences of preventing and treating obesity with lifestyle intervention in Switzerland.

Methods

Model description

A Markov decision model (Sonnenberg 1993) is developed to evaluate the lifetime effect of a three-year lifestyle intervention compared with standard care in overweight and obese people. Seven states are modeled: "overweight/obese", if patients are overweight or obese and free of complications, "hypertension" if patients are overweight or obese and developed hypertension (systolic blood pressure greater than 140 mmHg and diastolic blood pressure greater than 90 mmHg, JNC 1997), "hypercholesterolemia" if patients are overweight or obese and developed hypercholesterolemia (total serum cholesterol ≥ 6.2 mmol/l, EP 2001), "diabetes" if patients are overweight or obese and developed type 2 diabetes (fasting glucose of at least 7.8 mmol/l or 2-hour glucose of at least 11.1 mmol/l, Alberti 1998), "stroke", if patients are overweight or obese and developed stroke, "coronary heart disease" if patients are overweight or obese and developed coronary heart disease and "death": patients can die and enter this point at any time in the model.

A diagrammatic representation of the Markov model is presented in Fig. 1.

Subjects enter into the model in the 'overweight/obese' health state. The cycle length is one year. At the end of each one-year period, proportions of the cohort can move from one disease state to another or stay in the same disease state. The transition probabilities are based on the disease progression with age, sex, body mass index (BMI) and cycle number. The model is run over a period of 60 years to estimate the lifetime costs and effects of the intervention. Subjects entering the model have a minimum age of 25 years. The model runs until subjects reach the age of 85 years considering that the average life expectancy in Switzerland is 77.3 years for men and 82.8 years for women (World Health Organization 2005).

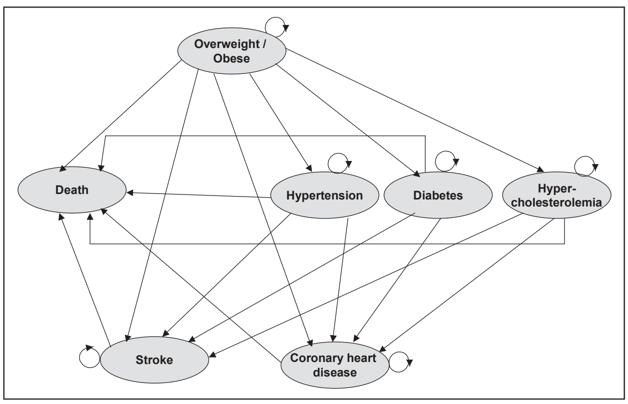

Figure 1 Markov model diagramm

Because of the complexity of the interrelationship between the degree of overweight/obesity and the five obesity-related complications, we made several assumptions. It is assumed that those diseases for which obesity is a risk factor are not interconnected and therefore are not counted as an additive effect on the lifetime health and costs in the model. For simplicity, the possibility of having concomitant diabetes, hypertension and hypercholesterolemia is not incorporated into the model. One reason for excluding the correlation between the existing co-morbidities is the absence of prevalence data for Swiss population. This assumption is most probably underestimating the burden associated with obesity co-morbidities.

A hypothetical cohort of 10,000 subjects overweight or obese receives a lifestyle program or standard care intervention for a period of three years. The components of lifestyle intervention are regular physical activity and healthy eating, including diets rich in fruits and vegetables. In our model, lifestyle intervention is adapted from Finish Diabetes Prevention Study (Lindström 2005) and consist in detailed dietary recommendations: to limit the total intake of fat to less than 30 % of energy consumed and of saturated fat to less than 10 %, and to increase fibre to at least 15 g/1000 kcal as well as advice about specific food types, and asked to undertake moderate exercise for at least 30 minutes per day. Lifestyle intervention group members attended dietitian sessions and supervised exercise sessions during the first three years. For overweight people, standard care consists in no intervention whereas for obese people standard care consists in basic dietary counseling and physical exercise sessions (see cost description section). Treatment effect is modeled as a reduction in BMI, systolic blood pressure, total cholesterol, and high density lipoprotein cholesterol based on data obtained in three-year active treatment. It is assumed that the effect of lifestyle intervention on cardiovascular risk factors and weight loss is maintained up to six years, thereafter subjects start to regain weight linear for a period of four years i.e. after ten years weight loss went back to the initial weight. This assumption is sustained by the extended follow-up of the Finnish Diabetes Prevention Study (Lindstrom 2006) which lasted 7 years and resulted in sustained lifestyle changes that were maintained after the individual lifestyle counselling stopped. The study reported a 43 % reduction in the relative risk related to the success in achieving the intervention goals of weight loss, reduced intake of total and saturated fat, increased intake of dietary fibre and increased physical activity. In the cost-effectiveness model, we assume that all patients developing hypertension, diabetes and hypercholesterolemia are diagnosed and treated. We also assume that patients remain in those states once they have entered, unless they develop cardiovascular disease or die.

Parameter estimates and data sources

We estimate our model using data from a variety of secondary sources, which we will describe in detail. A summary of the data input of the model is provided in the appendix.[1] The correlation between BMI and annual risk of developing hypertension, diabetes, and hypercholesterolemia is calculated based on two large American prospective, epidemiological studies: the Nurses Health Study and the Health Professional Follow-up Study, both summarized by Field et al. 2001. Intermediate values of BMI have been interpolated using the polynomial function. The risk of complications has been adjusted according to age, sex and prevalence of hypertension, diabetes and hypercholesterolemia based on the information provided by the Swiss health survey (SFSO 2006). The mean BMI by age and gender is obtained from World Health Organization country profile (2005) and Monica Project (Mähönen 2000).

The risk of developing coronary heart disease and stroke from "overweight/obese", "hypertension", "diabetes", "hypercholesterolemia" states are based on a risk equation from the Framingham cohort study (Anderson 1990). Risk factors are age, sex, systolic blood pressure, total cholesterol, high density lipoprotein cholesterol, presence of diabetes and smoking status. Data on systolic blood pressure, total cholesterol and high density lipoprotein of the Swiss population are obtained from Monica Project (Mähönen 2000). The mean systolic blood pressure increases with age in both men and women, rising from 127 mmHg in men aged 25-35 years to 145 mmHg in men aged 75 years and over, and from 115 to 144 mmHg in women. The mean blood cholesterol levels increases with age with a slight decrease in the oldest age group.

Mortality rates of overweight and obese subjects in the normal health state are assumed to be equivalent to those observed in the general population although there are studies that explored the relationship between BMI and the risk of death (Fontaine 2003, McGee 2005). Obesity and overweight in adults are found to be associated with large decreases in life expectancy and increases in early mortality. However, we decided not to include these increased mortality risks because there is a danger of double counting if the elevated mortality risks are combined with associated complication mortality rates.

Age and gender specific mortality data is obtained from Swiss Federal Statistical Office (2006): overall mortality data and disease specific according to International Classification of Diseases (ICD-10 codes): I10–I15 Hypertensive disease, I20–I25 Ischemic heart disease, I60–I69 Cerebrovascular disease and E10–E14 Diabetes mellitus. The yearly probability of diabetes, hypertension, coronary heart disease and stroke are obtained from the actual number of deaths and disease prevalence rates in Switzerland (SFSO 2006).

Data on the effectiveness of lifestyle intervention is obtained using meta-analysis technique (Saint 1999) of the randomized controlled trials performed in overweight and obese people. The aim of the meta-analysis is to combine the long-term effects of lifestyle intervention on weight and cardiovascular risk factors in overweight and obese people from several studies. The lifestyle intervention in all evaluated studies consisted in dietary counseling and physical exercise sessions and lasted from one to six years with an average follow-up time of three years. A summary of the meta-analyses results on the outcomes of interest is presented in Tab.1. Effects are combined using a random effects model. The summary outcome measure calculated is the difference in means between lifestyle intervention and standard care. The pooled estimates of effect size are obtained using Comprehensive Meta-Analysis software (CMA 2005).

Utility score represent the strength of patient preferences for their own health on a scale from 0.0 (death) to 1.0 (perfect health). Three published sources of utilities are used: utilities for overweight and obese people (Macran 2004), utilities changes due to decreases in BMI (Hakim 2002) and utilities associated with the complications of obesity (Jia 2005).

The data on resource used by subjects receiving lifestyle intervention or standard care are taken from Finnish Diabetes Prevention Study (Lindström 2005) and adapted for Switzerland. For lifestyle intervention, seven dietitian visits are assumed in the first year, and four visits per year thereafter. Based on the unit cost of the health care calculated for Switzerland, the dietician cost per visit is estimated at CHF 64 (Tarmed 2006). The same price is assumed for physical exercise which is done in group sessions of 20 people for one hour. The group attended four sessions per month in the first year and two sessions per month during the subsequent year. The total estimated costs of lifestyle intervention are CHF 602 per person in the first year and CHF 333 per person per subsequent year. In the standard control group, costs are assumed zero in overweight people. For obese subjects, the standard care consists in three dietitian visit in the first year, and one

[1] The appendix is available online only as supplementary material at www.birkhauser.ch/IJPH

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visit per year thereafter and the equivalent of two exercise sessions per month in the first year and one session per month during the subsequent year. The obesity medication costs are not considered in the standard therapy of obesity given that there are not chronic medications, i.e. the European prescribing guidelines state that the duration of treatment with orlistat should not be longer than two years (EMEA 1998). Thus, a conservative estimate is preferred. The total estimated costs of standard care intervention in obese subjects are CHF 369 per person in the first year and CHF 102 per person per subsequent year.

The costs of obesity complications are obtained from published literature and adjusted to 2006 Swiss prices using the consumer price index (SNB 2006). This included the average direct and indirect cost of the disease. A summary of the cost components and source of data is provided in Tab.2.

Cost-effectiveness analysis

In order to assess the effect of lifestyle interventions in the prevention and treatment of obesity, we defined three groups of people that are followed throughout the analysis: overweight group, borderline group and moderate obese group. The subjects in the overweight group have a BMI of 27 kg/m^2 selected from the overweight range of BMI 25 to 29.9 kg/m^2, the subjects from the moderate obese group have a BMI of 33 kg/m^2 selected from the moderate obesity range BMI 30 to 35 kg/m ^{2}and the subjects from the borderline group have a BMI of 30 kg/m^2 representing people who are at the upper limit of overweight and lower limit of obesity. For each group of people: overweight, borderline and moderate obese, the results are presented as difference between lifestyle and standard care intervention in mean costs, life-years (LY) and quality adjusted life-years (QALY). A subgroup analysis was performed in overweight subjects, borderline subjects and moderate obese subjects on different age groups (e.g. 25, 35, 45, 55 years) and gender to allow for a direct comparison among patient populations. Half cycle correction is applied to life expectancy calculations assuming that the transition will take place half way through a cycle.

The cost-effectiveness of interventions is compared using the incremental cost-effectiveness ratio, defined as difference in costs (C_L–C_S) divided by difference in effects (E_L–E_S). Given the chronic nature of the diseases incorporated in the model, a lower value of LY compared to QALY is expected. Our model

Table 1 Meta-analysis of lifestyle intervention effects in overweight and obese people

	Outcome	Number studies	Number participants	Difference in means	Standard error	95 % Confidence Interval	p-Value
Overweight	BMI (kg/m^2)	5	926	–1.11	0.23	–1.56, –0.66	<0.0001
	SBP (mmol/l)	9	2239	–2.08	0.61	–3.28, –0.89	0.001
	TC (mmol/l)	7	1516	–0.26	0.07	–0.41, –0.12	<0.0001
	HDL (mmol/l)	7	1875	0.01	0.01	–0.22, 0.04	0.640
Obese	BMI (kg/m^2)	7	3522	–1.33	0.31	–1.93, –0.72	<0.0001
	SBP (mmol/l)	6	4182	–2.78	0.82	–4.38, –1.18	0.001
	TC (mmol/l)	5	893	–0.14	0.05	–0.24, 0.03	0.011
	HDL (mmol/l)	4	2778	0.04	0.02	0.004, 0.08	0.028

Table 2 Cost components

Component	Cost[a] (CHF)	Reference
Lifestyle intervention in overweight/obese[b]	1268	Lindstrom 2005 adapted for Switzerland
Standard intervention in obese[b]	573	Lindstrom 2005 adapted for Switzerland
Hypertension	1653	Schmid 2005
Type 2 diabetes	2890	Schmitt-Koopmann 2004
Hypercholesterolemia	1245	Schmid 2005
Coronary heart disease	6242	Schmid 2005
Stroke	11495	Schmitt-Koopmann 2004

[a] Cost per person per year adjusted for 2006 prices
[b] Cost of three years intervention

comparatively calculates the incremental cost-effectiveness ratio as cost per LY in a cost-effectiveness analysis and as cost per QALY in a cost-utility analysis. Incremental costs were reported in Swiss Francs (CHF) and Euro (€) to allow for an international comparison (exchange rate 1 CHF = 0.607158 €, May 9, 2007). The analysis is performed from a society perspective. Future costs and effects are presented undiscounted and discounted at 3 % rate. The model is developed using Microsoft Excel Software.

Sensitivity analysis

A probabilistic sensitivity analysis (Briggs 2000) is carried out to investigate the robustness of the data input including the baseline risks of transitioning to obesity-complications, the lifestyle and standard care intervention effects, the utility values, the costs of complications, and the costs of interventions. In order to propagate uncertainty in our model, distributions are assigned to all model parameters that are estimated with uncertainty. The distributional forms of the model parameters are: normal distribution for the costs of interventions and cardiovascular risk factors, gamma distribution for the costs of obesity complications and beta distribution for utility scores. Values are drawn at random from the specified distributions using a random number generator for the chosen parameter. Monte Carlo simulation was used to propagate these distributions through the model by recalculating the results over a large number of iterations. The results of running the probabilistic sensitivity analysis by randomly sampling from the parameter distributions are presented on the cost-effectiveness plane (Briggs 1998) and cost-effectiveness acceptability curve (Fenwick 2004).

Results

The average difference in costs and effects between lifestyle intervention and standard care is presented in Tab.3. The lifestyle intervention resulted in increased survival and improved quality of life, equivalent to a difference of 0.05 LY and 0.33 QALY per person per year gained over lifetime. Compared with standard care, the average incremental cost of lifestyle intervention is lower in the borderline group (female CHF –281, male CHF –384) and the moderate obese group (female CHF –65, male CHF –176) and higher in the overweight group (female CHF 216, male CHF 124) when probabilistic results are undiscounted. When future costs and effects are discounted at 3 % rate, lifestyle intervention has lower costs than standard care in borderline male subjects (CHF –99). In the borderline group, the lifetime incremental cost per LY is estimated in female at CHF –15,000 (€ –9107) per LY and male at CHF –13,933 (€ –8460) per LY when results are undiscounted. When 3 % discount rate is applied, incremental cost-effectiveness ratio is CHF 1700 (€ 1032) per LY in borderline female subjects and CHF –11,200 (€ –6800)

Table 3 Incremental costs and effects per person per year

	Sex	Average [a]	Overweight [b]		Borderline [b]		Moderate Obese [b]	
			0 %	3 %	0 %	3 %	0 %	3 %
Deterministic	Female	Cost, CHF	234	510	–161	80	18	207
		Cost, €	142	310	– 98	49	11	126
		LY	0.02	0.01	0.02	0.01	0.02	0.01
		QALY	0.27	0.23	0.29	0.25	0.29	0.26
	Male	Cost, CHF	156	405	–260	–6	–70	127
		Cost, €	95	246	–158	–4	–43	77
		LY	0.03	0.01	0.03	0.01	0.02	0.01
		QALY	0.29	0.25	0.32	0.28	0.33	0.29
Probabilistic	Female	Cost, CHF	216	490	–281	16	–65	145
		Cost, €	131	298	–171	10	–39	88
		LY	0.02	0.01	0.05	0.01	0.02	0.01
		QALY	0.26	0.23	0.29	0.25	0.30	0.26
	Male	Cost, CHF	124	384	–384	–99	–176	44
		Cost, €	75	233	–233	–60	–107	27
		LY	0.03	0.01	0.03	0.01	0.03	0.01
		QALY	0.30	0.25	0.32	0.28	0.30	0.29

[a] Difference between lifestyle and standard intervention, average from age 25 to 65 years
[b] Lifetime results are presented undiscounted (0 %) and discounted (3 %)
CHF, Swiss Francs; €, Euro; Exchange rate 1 CHF = 0.607158 €

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per LY in borderline male subjects. Lifetime incremental cost per QALY in the borderline group is estimated in female at CHF –969 (€ –588) per QALY and male at CHF –1200 (€ –729) per QALY when results are undiscounted. When discounting is applied, incremental cost-effectiveness ratio is CHF 64 (€ 39) per QALY in borderline female subjects and CHF –354 (€ –215) per QALY in borderline male subjects.

Subgroup analysis is conducted on different age groups (Tab 4). The gray shaded cells show the dominant intervention strategies whose lifestyle intervention has lower costs and a higher health effect compared with standard intervention. The subgroup analysis estimates that lifestyle intervention dominates standard care in overweight female subjects aged 45 years, overweight male subjects aged 25 years, borderline female subjects aged 30 to 65 yeas, overweight male subjects aged 25 to 65, moderate obese female subjects aged 35 to 60 and moderate obese male subjects aged 25 to 60 years, when results are undiscounted. When discounting is applied to future costs and effects, lifestyle intervention dominates standard care in borderline female subjects aged 35 to 55 years, borderline male subjects aged 25 to 60 years, moderate obese female subjects aged 45 years and obese male subjects aged 55 years.

To reflect the uncertainty in the estimates, Fig. 2 presents a scatter plot of the mean differences in costs and QALY gained between lifestyle and standard care, derived from the Monte Carlo simulation, in borderline people. The x- and y-axis divide the graph into four separate quadrants, which represent the following scenarios for lifestyle versus standard care (clockwise from the top right): (a) more effective and more costly; (b) more effective and less costly; (c) less effective and less costly, and (d) less effective and more costly. The high concentration of points in quadrant (a) and (b) indicate that lifestyle intervention is more effective than standard care. For example in borderline the majority of the replicates lie in the quadrant (b), where lifestyle dominates standard care, 78 % simulations of the lifestyle intervention are cost-effective relative to standard care (Fig. 2). However, the dispersion of points above and below the x-axis, indicates that there is some uncertainty about whether this gain in QALY is achieved at a lower or higher cost than standard care. If the gain in QALY is achieved at a higher cost, then the critical issue that determines whether lifestyle intervention is cost-effective is how much (if any) the decision maker is willing to pay for an additional unit gain in health outcome.

Fig. 3 illustrates the cost-effectiveness acceptability curves for lifestyle compared to standard care intervention in borderline group. The curves indicate the probability of lifestyle intervention being more cost-effective than the standard care for a range of potential maximum amounts a decision maker is willing to pay for an additional unit of health gained. In our model we carried out the analysis for a range of values for the society willingness to pay for an additional unit of health gain. When the decision-maker is unwilling to pay anything additional for a health gain the probability that lifestyle intervention is cost-effective is 5 % in the overweight group, 78 % in the borderline group (Fig. 3.) and 47 % in the moderate obese group. If the decision-maker is willing to pay CHF 500 per QALY gained, the probability of the lifestyle intervention being cost-effective increases to 12 % in overweight subjects, 95 % in borderline subjects (Fig. 3) and 75 % in moderate obese subjects. Furthermore, if the decision-maker is willing

Table 4 Incremental cost-effectiveness ratio per person per year

	Sex[a]	ICER	Age 25[b]		Age 35[b]		Age 45[b]		Age 55[b]	
			0 %	3 %	0 %	3 %	0 %	3 %	0 %	3 %
Overweight	F	CHF/QALY	4,515	6,286	95	2,352	–419	1,131	508	1,366
		CHF/LY	76,734	295,863	834	45,551	–4311	23,126	7,278	33,482
	M	CHF/QALY	–374	1,854	395	2,014	324	1,457	237	914
		CHF/LY	–2,840	34,291	3,006	30,934	3,054	24,473	2,787	17,149
Borderline	F	CHF/QALY	1,534	3,023	–2,945	–1,630	–2,000	–785	–898	–173
		CHF/LY	27,510	142,619	–19,380	–6,050	–22,053	–17,106	–13,032	–4,250
	M	CHF/QALY	–2,560	–781	–283	–331	–1,373	–523	–1,027	–508
		CHF/LY	–19,496	–14,886	–14,196	–52,927	–14,158	–9,595	–13,282	–10,417
Obese	F	CHF/QALY	1,973	3,180	–982	–753	–1,026	–88	–355	173
		CHF/LY	39,925	171,544	–11,287	10,019	–14,496	–2,426	–6,670	5,481
	M	CHF/QALY	–1,453	3	395	276	–741	9	–502	–69
		CHF/LY	–12,657	58	–7,373	5,580	–8,912	185	–8,048	–1,745

[a] F – female, M – male;
[b] Lifetime probabilistic results are presented undiscounted (0 %) and discounted (3 %)

to pay CHF 1 000 per QALY gained, the probability of the lifestyle intervention being cost-effective increases further to 35 % in overweight subjects, 99 % in borderline subjects (Fig. 3) and 92 % in moderate obese subjects.

Fig. 4 and Fig. 5 present the cost-effectiveness acceptability curves in borderline subjects for different age groups in female and male. Overall, the cost-effectiveness for men is greater than for women. Lifestyle intervention is more cost-effective in female aged 35 to 55 years and male aged 25 to 55 years compared to other age groups.

Discussion

We defined based on BMI level three groups of people that are followed thought the study: overweight subjects (BMI 27 kg/m^2), borderline subjects (BMI 30 kg/m^2) and moderate obese subjects (BMI 33 kg/m^2). For the purpose of this study the classification allows us to differentiate prevention from the treatment of obesity and to better understand the importance of the transition from overweight to obesity reflected in the borderline group.

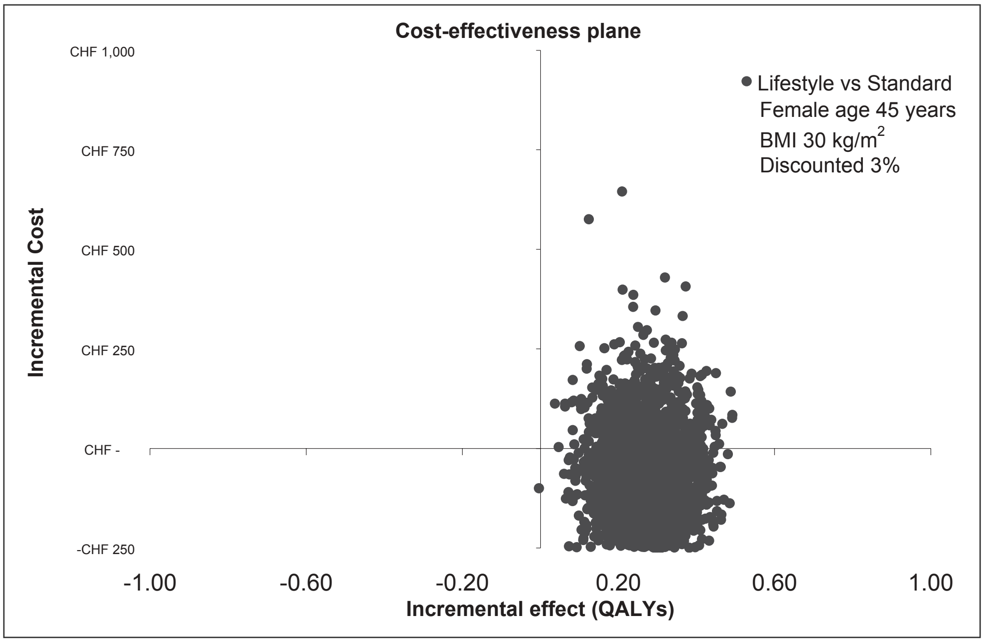

Figure 2 Scatter plot of the difference in mean costs and effects between lifestyle and standard care intervention

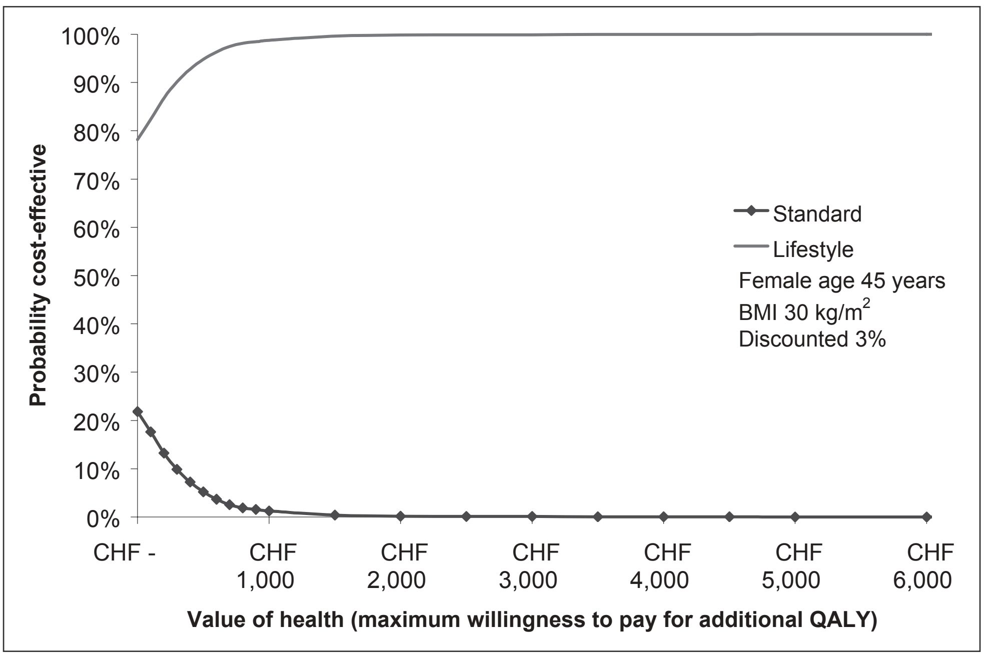

Figure 3 Cost-effectiveness acceptability curves lifestyle versus standard care intervention

Using a lifestyle intervention in overweight and obese people, the present model tries to quantify several elements of benefit associated with weight loss: first, a reduction in the risk of developing diabetes, hypertension, hypercholesterolemia and cardiovascular disease, second, an increase in life expectancy and quality of life, and third, a reduction in treatment costs by reducing the risk of developing obesity complications. In all three groups, independent of age, the lifetime effect of three-year lifestyle intervention resulted in increased survival and an improved quality of life compared with standard care. The difference in cost between lifestyle intervention and standard care is lower in borderline subjects and moderate obese subjects and higher in overweight subjects. In particular, in borderline people lifestyle intervention dominates standard care intervention being less costly and more effective. The majority of the costs savings in borderline group are attributable to a decrease in the risk of developing obesity complications. Despite the lifestyle interventions incurring higher mean costs in the first three years, these additional costs are offset by the reduced probability of developing obesity related complications. The subgroup analyses differentiate the cost-effectiveness for each age group. We observed some im-

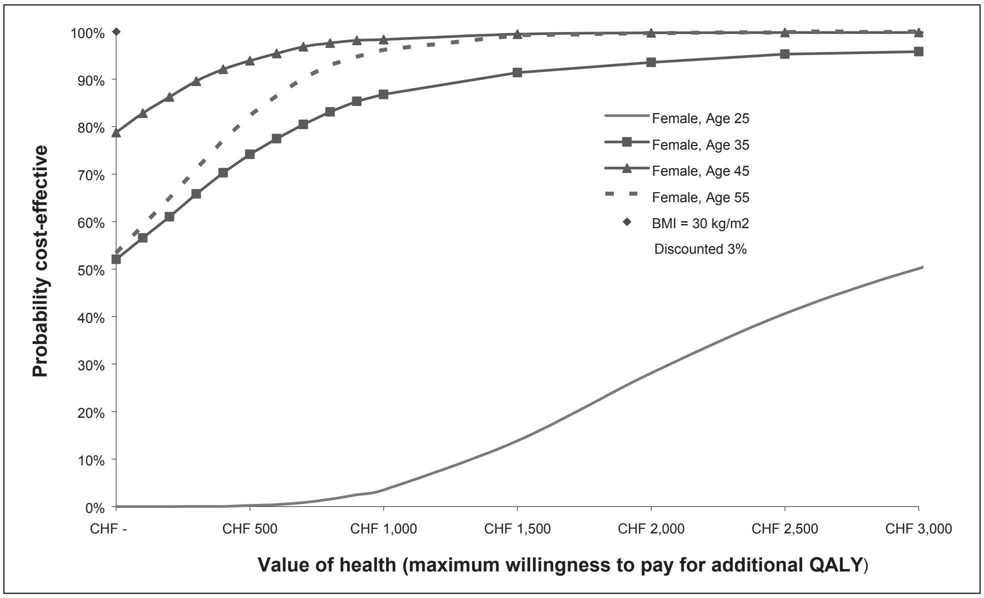

Figure 4 Cost-effectiveness acceptability curves of lifestyle intervention in female

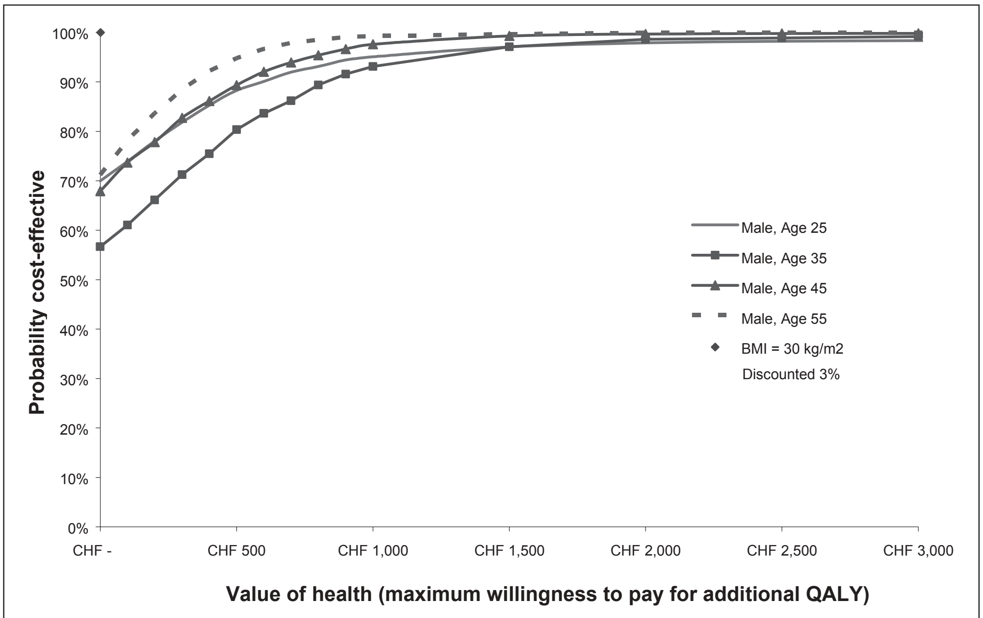

Figure 5 Cost-effectiveness acceptability curves of lifestyle intervention in male

portant gender differences. Firstly, the incidence of diabetes is higher in men resulting in higher cost saving for men aged 25 to 35 years compared with women in the same age group. Secondly, women have a lower mortality rates and, as a consequence, higher life expectancy compared to men resulting in higher costs associated with obese co-morbidities. Thirdly, investigations have suggested that weight gain during and after menopause may contribute more to cardiovascular disease than actual weight prior to menopause and that weight loss and increase physical activity may mitigate some of the cardiovascular risk factors i.e. high cholesterol, insulin resistance (Carels 2004, Matthews 1989). These observations are consistent with our findings that weight loss with lifestyle intervention is more cost-effective in women aged 45-55 years due to a decrease in the cardiovascular risk factors compared with standard care intervention.

The current analysis suggests that borderline people who are at the upper limit of overweight and lower limit of obesity benefit the most from a lifestyle intervention lasting for three years. The lifetime effect of a lifestyle intervention is reflected in lower costs and higher effects. This may be considered a critical point in the prevention of obesity. It has been suggested that reducing the risk factors that diseases have in common may prove to be an efficient prevention strategy (Epstein 1983). For example, several risk factors such as obesity, physical inactivity, hypertension, hyperglycaemia and hypercholesterolemia predict the development of chronic diseases such as diabetes and cardiovascular disease. Therefore, a successful preventive program based on lifestyle intervention may target several risk factors simultaneously.

One issue of concern in the cost-effectiveness analysis is that societal threshold, the maximum willingness to pay for one unit of health gain, is not known. It has been suggested that incremental costs of less than CHF 24,178 (€ 14,680) per QALY are considered cost-effective representing strong evidence for adoption (Laupacis 1992); however, the acceptance value is a subject highly debated in the literature. For example, the National Institute for Clinical Excellence in the United Kingdom evaluated orlistat and sibutramine for the treatment of obesity in adults and determined the cost-effectiveness of orlistat at values ranged from CHF 25,093 to CHF 110,987 per QALY (NICE report 31) and of sibutramine at values ranged from CHF 25,334 to CHF 72,383 per QALY (NICE report 22). In Switzerland, the cost-effectiveness of orlistat was estimated at CHF 22,413 (€ 13,608) per QALY (Ruof 2005). The Swiss authorities decided to reimburse orlistat in the treatment of diabetic patients with BMI $\geq 28\,kg/m^2$, but stipulated that it should be continued beyond six months only in patients who lose ≥ 5 kg of their starting weight or achieve a reduction in HbA1c of $\geq 0.5\,\%$ (Ruof 2005).

To compare the results of our study with other economic analyses performed in overweight and obese people we reviewed the published economic literature on lifestyle interventions. An economic analysis was performed in the American Diabetes Prevention Program (DPP) in obese people with impaired glucose tolerance (Herman 2005). Compared with standard care intervention, lifestyle intervention cost CHF 768 more over a lifetime and produce a gain of 0.57 QALY, resulting in a cost per QALY of approximately CHF 1330 (€ 808). Another modelling study performed in the DPP (Eddy 2005) estimate the 30-year cost per QALY of lifestyle intervention compared with the control group at CHF 74,953 (€ 45,508). The authors suggest that using lifestyle intervention until after a person develops diabetes would be more cost-effective (CHF 29,619 per QALY). In United Kingdom, an economic analysis of lifestyle intervention in obese people at risk of diabetes, estimates the 15-year incremental cost per QALY at CHF 14,054 or € 8533 (Avenell 2004). It has been also documented that non-pharmacological treatments that target severe obesity (BMI $>35\ kg/m^2$) are cost-effective (Tsai 2005). The fact that certain treatments are cost-effective in high risk individuals with severe obesity or associated co-morbidities i.e. diabetes, cardiovascular disease does not answer the question of the cost-effectiveness of the same interventions for lower risk obese or overweight individuals, whose prevention or treatment benefits may also be worth the cost. To answer this question, a better understanding of the implications of weight loss and improvement of risk factors for long-term health outcomes is necessary in overweight and moderate obese people. Policy makers need country specific economic data on overweight and obesity to tackle the growing burden of obesity. Our cost-effectiveness analysis illustrates from a Swiss perspective the lifetime impact of lifestyle intervention in the prevention and treatment of obesity. The obtained results provide an argument for organizations and institutions actively involved in the field of obesity prevention to justify funds for intensified prevention strategies using lifestyle interventions.

Our analysis also has several limitations. The model could be improved by having access to additional Swiss-specific data. So far, epidemiological data such as the correlation between BMI and the risk of complications, obesity related mortality data and changes in patient utility for weight loss have not been recorded specifically for Switzerland. Further investigations should also take into account other important complications of obesity such as metabolic syndrome, colorectal cancer, gall bladder disease, sleep apnea and depression. Our model does not take into consideration smoking as a risk factor although it has been documented that obese smokers have a decrease in life expectancy compared with non-smok-

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ers (Sempos 1998). Another limitation of our study consists in the estimation of the costs of obesity complications from secondary data sources. In our model, the cost of stroke represents the largest value among all complications. However, this high cost is confirmed by various costs of illness studies performed in Europe (Kolominsky-Rabas 2006, Gerzeli 2005). Overall, our model reflects a conservative approach considering that we do not include obesity medication, all related obesity complications and correlations between diseases incorporated in the model. Although our analysis simplifies the complex reality, it provides a first positive estimate on the lifetime impact of lifestyle intervention on overweight and obese people in Switzerland.

Conclusion

In summary, prevention and treatment of obesity must be a priority for heath care decision makers across Europe giving the rapid increase in prevalence. With the aid of a decision analytic model, we synthesised Swiss specific evidence available on the outcomes and costs of lifestyle intervention and standard care in overweight and obese people. Our economic analysis suggests that lifestyle intervention is cost-effective in the long-term prevention and treatment of obesity in Switzerland.

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Zusammenfassung

Ökonomische Beurteilung von Therapien zur Verhaltensänderung (lifestyle interventions) in der Prävention und Behandlung von Übergewicht und Adipositas in der Schweiz

Zielsetzung: Ziel dieser Arbeit war es ein Entscheidungsbaum-Modell zu entwickeln um die gesundheitlichen und wirtschaftlichen Auswirkungen von Verhaltensänderungstherapien (lifestyle interventions) zur Prävention und Behandlung von Adipositas in der Schweiz zu untersuchen.
Methoden: Markov-Modell, Verhaltensänderungstherapie vs. Standardtherapie bei übergewichtigen und adipösen Personen. Veränderungen des Körpergewichts und der kardiovaskulären Risikofaktoren (systolischer Blutdruck, Gesamtcholesterin, HD-Lipoproteine) wurden bei 3 Personengruppen (Übergewichtigen, „borderline" und Adipösen) modelliert und mittels probabilistischer Sensitivitätsanalyse überprüft. Vergleich der Kosteneffektivität der beiden Behandlungen anhand inkrementeller Kosteneffektivitätsquotienten.
Resultate: Therapien zur Verhaltensänderung bei Übergewicht und Adipositas führen zu längerer Lebensdauer bei höherer Lebensqualität.
Verglichen mit der Standardtherapie sind die inkrementellen Kosten einer Verhaltensänderungstherapie geringer in der „borderline" und der adipösen Gruppe, höher hingegen bei den Übergewichtigen. Die Verhaltensänderungstherapie dominiert die Standardtherapie bei „borderline" Frauen (35 bis 55 Jahre), bei „borderline" Männern (25 bis 60 Jahre), bei adipösen Frauen (45 Jahre) und bei adipösen Männern (55 Jahre).
Schlussfolgerungen: Therapien zur Verhaltensänderung zur längerfristigen Prävention und Behandlung der Adipositas erscheinen kosteneffektiv.

Schlüsselbegriffe: Kosteneffektivität – Verhaltensänderung – Übergewicht – Prävention – Adipositas – Behandlung.

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