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Cost impact of blood glucose self-monitoring on complications of type 2 diabetes: a Swiss perspective (ROSSO study No. 11)

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Summary

Question under study: despite the increasing prevalence of type 2 diabetes, its financial burden on the Swiss healthcare system remains unclear. Our aim was to determine the cost of self-monitoring of blood glucose (SMBG) in reducing diabetic complications by comparing the direct costs to the Swiss statutory health insurance system of diabetic complications in SMBG users vs. nonusers.

Method: matched pair analysis of the average annual total cost of diabetes monitoring, treatment-related services, complications and follow-up in the RetrOlective Study Self-Monitoring of Blood Glucose and Outcome in Patients with Type 2 Diabetes (ROSSO) study cohort, updated to 2005 from the year of occurrence or diagnosis of diabetes, applying an annual inflation rate of 5%.

Results: in those patients treated with oral antidiabetic drugs only, total annual costs were CHF 5,140 in SMBG users and CHF 5,654 in nonusers. In those patients treated with oral antidiabetic drugs plus insulin, total annual costs were CHF 8,254 and CHF 11,776, respectively. SMBG accounted for 1.6% to 1.7% of total costs.

Conclusion: cost analysis indicates that SMBG provides a rapid return on initial investment.

Key words: diabetes type 2; self-monitoring of blood glucose; cost; cost of illness; Switzerland

Introduction

Despite the increasing prevalence of type 2 diabetes worldwide, there is considerable uncertainty in Switzerland, as in most European countries, over the actual prevalence figures and resulting financial burden on the (Swiss) healthcare system. The last sound assessment of diabetes-related costs in Switzerland, valid for 1999, indicated average costs for type 2 diabetic patients treated with oral antidiabetic drugs (OAD) alone of CHF 3,508 [1], rising to CHF 5,779 for those treated with OAD plus insulin [1].

The cost-effectiveness of self-monitoring of blood glucose (SMBG) in type 2 diabetes remains disputed. Randomised controlled trials have yielded conflicting results [2–8], possibly due, in most cases, to small sample size and hence lack of statistical power. Based on newer studies incorporating the need to train patients in interpreting their glucose results [7–9], three recent meta-analyses show a significant impact of SMBG on HbA_{1c} [10–12]. However, this reported reduction in HbA_{1c} levels has its own limitations, in that surrogate parameters are less satisfactory than patient-relevant endpoints.

A German multicentre epidemiological cohort study has recently shown the positive impact of SMBG on long-term diabetes endpoints [13]. Total nonfatal micro- and macrovascular event rates were lower among SMBG users than nonusers (7.2% vs. 10.4%, P = 0.002), as were fatal event rates (2.7% vs. 4.6%, P = 0.004). Cox regression analysis identified SMBG as an independent predictor of morbidity and mortality, with adjusted hazard ratios reduced to 0.68 (95% confidence interval [CI] 0.51–0.91, P = 0.009) and 0.49 (95% CI 0.31–0.78, P = 0.003), respectively. Both endpoints were also significantly lower among SMBG users in the population receiving oral antidiabetic drugs (OAD) only.

The aim of our analysis was to calculate the direct costs to the Swiss statutory health insurance system of SMBG and type 2 diabetes-related complications over a defined number of years based on the RetrOlective Study Self-Monitoring of Blood Glucose and Outcome in Patients with Type 2 Diabetes (ROSSO) study material and a Swiss cost data set.

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Methods

ROSSO was a longitudinal retrospective epidemiological cohort study performed in 2003 and 2004 across 192 German practices including a total of 3,268 type 2 diabetic patients diagnosed between 1995 and 1999. Physician records were searched for demographic and clinical data (body weight, blood pressure, blood glucose, blood glucose control, blood lipids, treatments, operative procedures, nonfatal events [myocardial infarction, stroke, foot amputation, loss of vision, renal failure requiring dialysis] and overall mortality) yearly from diagnosis to the year of withdrawal or study cut-off (2003). Mean follow-up was 6.5 years.

The representativity of the data depends on the representativity of the included practices. It was checked whether the types of the selected practices (treated patients per year, location of the practice, qualification of the physician) is in agreement with the official distribution data in Germany. A good agreement could be found. Some considerations about the data sensitivity are published in the paper (Martin et al. [13]).

The primary aim was to determine the influence of SMBG for at least 1 year on diabetic morbidity and mortality, described quantitatively by corresponding hazard functions. Use of SMBG may depend on individual conditions (age, concomitant disease, blood glucose control, diabetes treatment) that independently influence morbidity and mortality, thus potentially biasing direct comparison of hazard functions between SMBG users and nonusers. Hazards were therefore adjusted to similar conditions for both groups using Cox regression based on the proportional hazard rate model [13].

In the absence of appropriate regression models for deriving unbiased comparisons of direct costs between SMBG users and nonusers, modified matched-pair analysis was used. The total cohort data were stratified into subgroups according to age (<55, 55–60, 60–65, 65–70, >70 years), gender (male, female), smoker (smoker, nonsmoker, ex-smoker) and fasting blood glucose (FBG) at diagnosis (<7.2, 7.2–9.4, >9.4 mmol/l). Subgroups were built up by combining classes of the four stratifying variables. Equal numbers of SMBG users and nonusers were randomised to each subgroup from the total cohort. Thus if a subgroup had fewer SMBG users than nonusers, the same number of nonusers was randomly selected from the subgroup, while if nonusers were fewer, the same number of users was randomly selected. This approach generated a random sample with 813 SMBG users and 813 nonusers similar in age, gender, smoking habits and baseline FBG (tables 1 and 2) for cost comparison purposes. The unit costs were updated to 2005 from the year of occurrence or diagnosis of diabetes, applying annual inflation rates corresponding to the general price development of health care in Switzerland (Swiss Federal Statistical Office [Bundesamt für Gesundheit] "Preisstatistik". Retrieved from www.statistik.admin.ch between 2004 and 2006).

To obtain the specific costs for the SMBG users and nonusers the observed events and services (i.e., complica-

Table 1

Baseline demographics and smoking status [n (%)].

		SMBG before nonfatal event		Group total
		Yes	No	
Gender	Male	417 (51)	417 (51)	834 (51)
	Female	396 (49)	396 (49)	792 (49)
Group total		813 (100)	813 (100)	1,626 (100)
Smoking status	Smoker	175 (22)	175 (22)	350 (22)
	Non-smoker	551 (68)	540 (66)	1,091 (67)
	Ex-smoker	87 (11)	98 (12)	185 (11)
Group total		813 (100)	813 (100)	1,626 (100)

Table 2

Baseline clinical parameters.

		SMBG before nonfatal event			
		Yes		No	
		Mean ± SD	Evaluable (n)	Mean ± SD	Evaluable (n)
Age (years)		61.3 ± 9.2	813	61.7 ± 9.5	813
Body mass index (kg/m^2)		29.8 ± 4.9	696	29.9 ± 5.2	649
Blood pressure (mm Hg)	systolic	148 ± 21.2	731	149 ± 18.8	698
	diastolic	87 ± 11.7	731	86 ± 10.3	698
Total cholesterol (mmol/l)		6.0 ± 1.3	630	6.2 ± 1.3	634
Triglycerides (mmol/l)		2.6 ± 2.0	506	2.7 ± 1.9	512
HDL-cholesterol (mmol/l)		1.3 ± 0.7	253	1.2 ± 0.4	279
LDL-cholesterol (mmol/l)		3.8 ± 1.2	200	3.8 ± 1.2	215
HbA_{1c} (%)		7.9 ± 2.3	427	7.4 ± 1.8	369
Fasting plasma glucose (mmol/l)		9.4 ± 4.1	813	9.27 ± 3.5	813
Serum creatinine (µmol/l)		86.6 ± 23.9	596	83.1 ± 18.6	617

Table 3

Cumulated events occurred during the observation period in OAD-only- and OAD-plus-insulin-treated patients.

	SMBG before nonfatal event			
	OAD only		OAD plus insulin	
	Yes	No	Yes	No
Complication				
Coronary heart disease (%)	6.5	9.4	13.6	21.7
Heart failure (%)	10.2	6.6	9.7	9.4
Myocardial infarction (%)	2.1	4.5	2.2	10.3
Stroke (%)	5.3	7.3	5.0	12.6
Peripheral arterial disease (%)	10.2	8.4	11.5	12.6
Depression (%)	4.9	10.3	11.7	14.6
Bypass surgery (%)	1.6	4.6	2.2	5.7
Angiography (%)	4.1	5.9	3.9	5.7
Coronary angioplasty (%)	0.9	2.4	2.8	1.5
Carotid endarterectomy (%)	0.3	0.2	1.1	0.0
Foot ulcer (%)	3.5	4.3	3.8	6.7
Foot amputation (%)	0.3	0.4	2.6	1.5
Blindness (%)	0.0	0.0	0.7	1.5
Cataract surgery (%)	5.3	7.1	1.6	5.2
Retinal laser coagulation (%)	0.0	0.0	1.8	0.0
Dialysis (%)	0.5	0.0	3.5	5.4
Hypoglycaemia (%)	1.4	0.9	1.1	1.5
Polyneuropathy (%)	14.9	9.1	24.8	25.9
Consultations				
Average physician visits in observation period (n)	137	142	176	170
Monitoring				
Average test strips per year (n)	38.8	0	71.5	0
Antidiabetic treatment				
Alpha-glucosidase inhibitor (%)	11	9	9	11
Metformin (%)	38	40	35	38
Sulfonylurea (%)	44	45	48	54
Others (e.g., glitazones) (%)	7	6	n.d.	n.d.
Insulin (%)	0	0	60	54

Table 4

Cost (CHF) of diabetic complications updated to 2005.

Complication	Year 1 cost	Cost after year 1	Reference
Coronary heart disease	9,187	9,187	[17]
Heart failure	23,747	23,747	[17]
Myocardial infarct	19,460	1,823	[17] [18]
Stroke	39,315	20,167	[17] [18]
Peripheral arterial disease	8,113	8,113	[19] [20]
Depression	6,218	6,218	[21]
Bypass surgery	17,728	–	[17]
Angiography	5,322	–	[22]
Coronary angioplasty	6,268	–	[17]
Carotid endarterectomy	8,818	–	[17]
Foot ulcer	21,863	–	[23] [24]
Foot amputation	48,008	–	[25]
Blindness	22,644	22,644	[26]
Cataract surgery	800	–	[27]
Retinal laser coagulation	1,253	–	[28]
Dialysis	81,220	81,220	[29]
Hypoglycaemia	1,045	–	[25]
Polyneuropathy	769	769	[30] [20]
General practitioner visits (10.3/year)	846	846	[1]

Table 5

Cost (CHF) of SMBG items.

Item	Cost
Device	125
Test strips (n = 102)	108
Lancets (n = 200)	3

Table 6

Weighted cost of recommended daily dosages (CHF) of antidiabetic medication averaged from products available in Switzerland.

Medication	Cost
Alpha-glucosidase inhibitor	1.08
Metformin	0.60
Sulfonylurea	1.35
Others (e.g., glitazones)	3.84
Insulin	2.43
References: [31] [32]	

tions, physician visits), the applied antidiabetic medication and, where applicable, the number of test strips (table 3) where multiplied by the corresponding unit costs (table 4, row "Year 1 cost" and tables 5 and 6). For patients surviving an initial event the medical follow-up cost (e.g., AMI, stroke, etc.) were calculated by multiplying the corresponding follow-up unit costs listed in table 4, row "Cost after year 1".

Results

In SMBG users vs. nonusers, total annual costs per patient year were CHF 5,140 vs. CHF 5,654 in those treated with OAD only, and CHF 8,254 vs. CHF 11,776 in those treated with OAD plus insulin (figures 1 and 2).

Costs of initial events and surgical intervention

In the OAD-only cohort, mean costs per patient-year of initial complications (e.g., first acute myocardial infarction) and surgical interventions

Figure 1

Cost per patient-year (CHF) in cohort using oral antidiabetic drugs only.

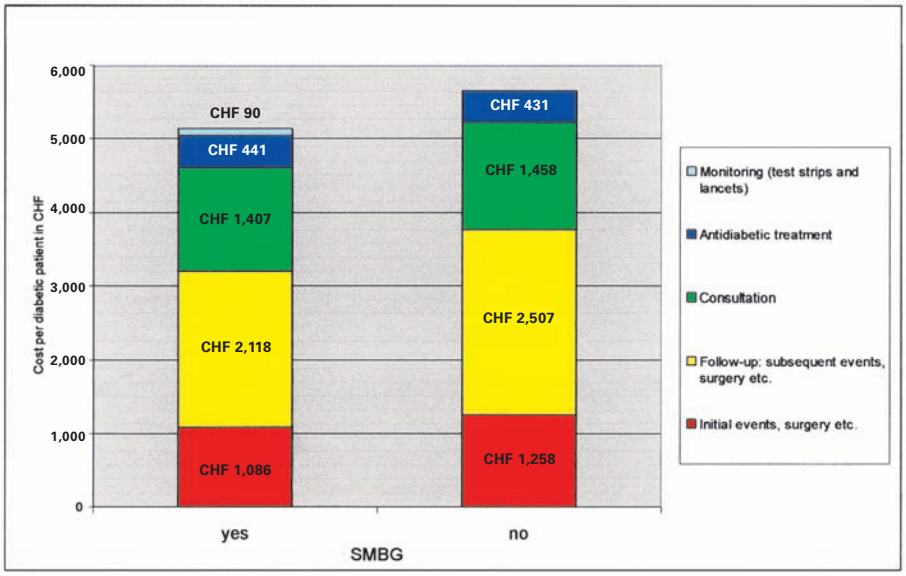
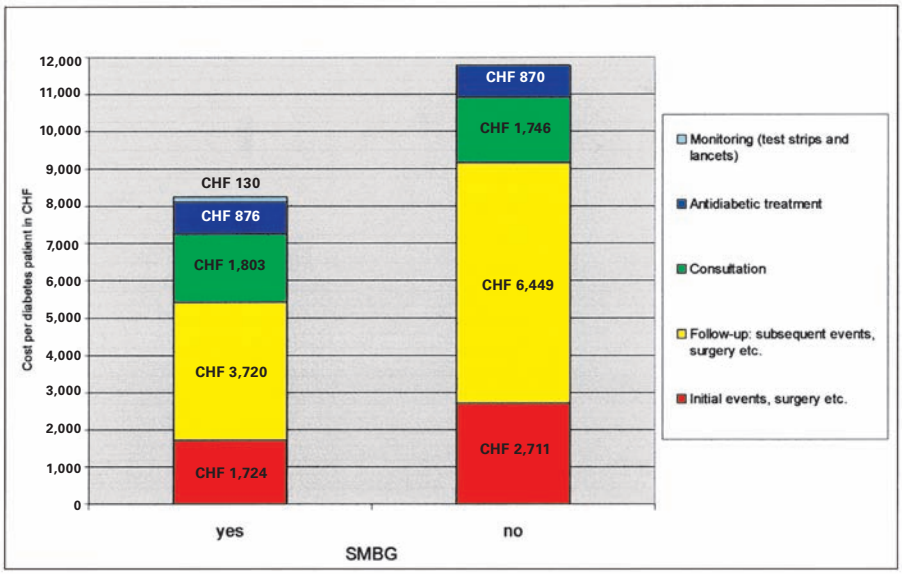


Figure 2

Cost per patient-year (CHF) in cohort using oral antidiabetic drugs + insulin.



(e.g., amputation) were CHF 172 lower in SMBG users, while in the OAD + insulin cohort they were CHF 987 lower in SMBG users.

Cost of follow-up and subsequent surgical intervention

The same trends were observed in the follow-up costs of diabetic complications, with savings of CHF 389 and CHF 2,729 among SMBG users treated with OAD only and OAD + insulin.

Consultation costs

Consultation costs in the OAD + insulin cohort were CHF 57 higher in SMBG users than in nonusers. In OAD-only SMBG users, on the other hand, the annual saving was CHF 51.

Antidiabetic medication costs

Annual antidiabetic medication costs among SMBG users in the OAD cohort were CHF 10 higher than in nonusers. In the OAD + insulin cohort, costs were CHF 6 higher among SMBG users.

Monitoring costs

Blood glucose meters, strips and lancets accounted for 1.7% and 1.6% of total costs in the OAD-only and OAD + insulin cohorts. Assuming a 7.2% prevalence of diabetes in the Swiss population, we have 533,000 patients with diabetes in Switzerland, of whom 450,000 with type 2 diabetes. We assume furthermore that 50% of the latter are treated with OAD, 25% with OAD and/or insulin and 50% of patients perform SMBG. If we project the calculated savings to patients actually not performing SMBG, the use of SMBG could save the Swiss statutory health insurance system approximately CHF 255 million per annum.

Discussion

Epidemiological data on the prevalence and incidence of type 2 diabetes are poor in most European countries. No specific data have been published for Switzerland. Given their roughly comparable culture, lifestyle, geographic situation and statutory health care systems, it appears fair to assume that Switzerland and Germany are similar in their incidence and prevalence of diabetes and its complications. We therefore calculated the overall savings on the basis of a prevalence of 7.2% [14].

The most recent calculation of diabetes costs for Switzerland, valid for 1999, was published in 2004 [1]. It showed an average cost of CHF 3,508 per patient-year, reflecting a population based cost including all types of treatments (diet, oral, insulin). Given the 29% increase in Swiss healthcare costs since 1999, this corresponds to CHF 4,525 in 2005, which comes close to the mean cost of OAD-only treated patients. Possible explanations for the difference include different disease severity in the cohorts observed and wider-ranging collection of diabetic complications (e.g., mental disorders).

Davidson has argued that SMBG by non-insulin-using diabetic patients is a waste of money [15]. However, the discussions accompanying and following publication of new meta-analyses show that evidence is still conflicting. Many of the SMBG trials conducted thus far have been insufficiently powered to detect a significant impact and thus individually cannot reliably conclude whether SMBG influences HbA_{1c} or not [16]. In an attempt to clarify the debate, Jansen performed a meta-analysis of more recent randomised trials, concluding that SMBG reduces HbA_{1c} by a modest but significant 0.40% [12].

Randomised controlled trials are generally considered the gold-standard approach, but this depends on the question they are designed to answer. Studies assessing potential benefits and drawbacks should use patient- rather than disease-relevant endpoints. The ROSSO study was the first worldwide to analyse the relationship between SMBG and patient-related endpoints such as diabetic complications instead of a surrogate endpoint such as HbA_{1c}.

Although we used a widely accepted method of cost allocation for events and resource consumption, it has some inherent limitations. For example, retrospective cost allocation can only consider the most relevant aspects of a disease; this yields a picture less complex than the reality, but – we would argue – it is still sufficient to answer the questions asked. In addition, the costs applied are means, and do not account for differences in disease severity. It should also be borne in mind that ROSSO was a German multicentre study, and that there may be relevant differences between medical facilities, such as doctors' offices and outpatient clinics compared to Switzerland. However, we believe that none of these limitations suffice to invalidate our economic analysis of the ROSSO data showing that SMBG provides a rapid return on initial investment.

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