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DIABETES

Direct medical costs of type 2 diabetes and its complications in Switzerland

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Background: This paper analyses the direct medical costs of type 2 diabetes and its complications in Switzerland. Methods: Individual healthcare resource consumption related to type 2 diabetes and its complications was determined retrospectively in 1479 non-incident and non-dying patients over 12 months (1998–1999). Literature-derived attributable risks were used to correct for non-diabetes related macrovascular disease. Results: A total of 111 primary care physicians from 19 cantons throughout Switzerland participated. Their diabetic patients on average had 10.3 consultations per year related to this disease (95% CI: 10.0–10.7). Patients spent on average 2.7 days (95% CI: 2.2–3.3) per year in hospital due to diabetes and diabetes-related complications. Mean annual type 2 diabetes-related direct medical costs per patient amounted to CHF 3,508 / € 2,323 (95% CI: CHF 3,140–3,876 / € 2,080–2,567). They were particularly high in patients with insulin treatment or with complications. After application of attributable risks and a correction for the use of adjuvant materials, costs were CHF 3,324 / € 2,201. Assuming 250,000 patients with type 2 diabetes in Switzerland leads to an estimate of CHF 0.88 billion spent for this disease and its complications in 1998. This represents a share of about 2.2% of the country's total healthcare expenditures. Conclusion: These findings demonstrate the high economic importance of type 2 diabetes and its complications in Switzerland.

Keywords: cost of illness, economics, Europe, Switzerland, type 2 diabetes

Type 2 diabetes mellitus is one of the great challenges in public health. The number of people suffering from diabetes worldwide was estimated by the WHO at 135 million in 1995. This figure was projected to more than double by the year 2025, the reasons being ageing of the population, unhealthy diet, a sedentary lifestyle and subsequent obesity.[1,2] In relative terms about 2.1% of the world's population have diabetes, a number which is expected to increase to 3.0% by 2010.[2] Type 2 diabetes accounts for approximately 90% of all cases of diabetes in the world.

Besides its increasing health impact the economic burden of diabetes is enormous. A study conducted by the World Bank found that of 1,362 million DALYs lost to all illnesses in 1990, 7.97 million DALYs (0.59%) were lost to diabetes.[3] In the USA diabetes is known to be a major source of morbidity, mortality and economic expense.[4,5] US direct medical and indirect expenditures attributable to diabetes in 1997 were estimated at $ 98.2 billion.[5]

No empirical studies are available of the healthcare costs of diabetes in Switzerland, apart from a cost-effectiveness analysis of different management strategies for type 1 diabetes and two modelling studies on type 2 diabetes.[6–8] Data from other European countries cannot be assumed to be *a priori* applicable to Switzerland due to differing healthcare and pricing systems. This is even more true for the results of a relatively large number of US studies addressing this subject.

The aim of this study was to determine the direct medical costs of type 2 diabetes mellitus and its complications in Switzerland. A 'bottom-up' approach was used, as there are only very few aggregate healthcare data available in Switzerland. Calculations were based on the costs of the individual units of service performed.

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METHODS

Physician and patient sample

From the Swiss Medical Association's 1998 list, 3,100 primary care physicians were randomly selected and invited to participate if they treated 10 or more diabetes patients. A total of 111 general practitioners and non-subspecialized internists from all over Switzerland provided information extracted from their medical charts. They were asked to include *all* patients with type 2 diabetes who attended their office during the last 12 months, in order to minimize possible selection biases. Classification of diabetes was left to their judgement and not influenced by the study group.

Data were collected between June 1998 and September 1999. Patients who were newly diagnosed or died within the reviewed time period were excluded to avoid distortions by observations with extreme values. The exclusion of newly diagnosed cases implies a strictly prevalence-based approach.

Patient data and healthcare resource utilization

Diabetes-related healthcare utilization and cost-inducing events were recorded for 12 months retrospectively. Collection of data included gender, age, age at diagnosis, type of treatment, the presence of microvascular complications (neuropathy, nephropathy, retinopathy), macrovascular complications (coronary heart disease, cerebrovascular disease, peripheral artery disease), and related events. At the resource use level, recording comprised diabetes-related medication, consultations, laboratory tests, imaging diagnostics, ambulatory procedures, hospital stays, and home healthcare. Insurance and employment status were also recorded, as well as the number of working days lost. The use of adjuvant materials like glucose monitoring devices, strips and syringes could not be assessed from the medical charts. It was estimated, at the aggregate level, from the experience available in a large Swiss outpatient diabetes unit.

Clinical data

Although resource utilization was the primary interest of this study, selected clinical data, which were felt to be important for further analyses, were also recorded. Parameters included height, weight, last measurements of laboratory parameters (plasma glucose, HbA1c, total cholesterol, HDL-cholesterol, triglycerides, serum creatinine, and urine albumin excretion), and the last recorded blood pressure measurement.

Costs

To estimate the economic impact of type 2 diabetes and its complications, direct medical costs were calculated. Prices and charges were used as proxy measures of real costs. All expenditures on the resources used were taken into account independently of the payer (patient, third-party, or state). In this sense, a societal perspective of cost assessment was adopted.

Direct medical costs comprised expenditures for outpatient care (consultations of general practitioners and specialists, laboratory tests, imaging diagnostics, ambulatory surgeries, prescribed outpatient nursing services and education by nurses), in-patient care (hospitalizations, inpatient procedures), and medication. Treatment costs of diabetes-related complications (neuropathy, nephropathy, eye complications, and macroangiopathy) were also included. Services provided by physiotherapists or dieticians and the costs of long-time hospice care could not be assessed. The costs of adjuvant materials were estimated at an aggregate level. All expenditure calculations were based on 1998/1999 prices and tariff lists.

Costs of outpatient care

To estimate the costs induced by consultations of general practitioners, the number of visits was multiplied by the applicable consultation fees. To estimate the expenditures for out-patient care provided by ophthalmologists, the number of diabetes-related visits was multiplied by the sum of charges for the typical services covered.

The number of laboratory tests performed was multiplied by the applicable tariffs.[9] The costs of imaging diagnostics (X-rays, Doppler sonography, computer tomography and magnetic resonance imaging), of outpatient eye surgeries, of prescribed home care services, and of diet counsel and education by diabetes nurses were assessed according to the same principles.[10,11]

Costs of in-patient care

Estimates of in-patient care costs included costs of hospitalization and of inpatient interventions (PTCA, PTA and bypass surgery) as well as costs of haemodialysis.

Table 1 Demographic data of study population (N=1479)

	Value (mean ± SD or %)
Age (years)	66 ± 12.3
Male/Female (%)	49.4 / 50.1
German/French/Italian speaking (%)	82.9 / 16.2 / 0.9
Height (cm)	167 ± 9.13
Weight (kg)	81.2 ± 16.55
BMI (m/kg^2)	29.4 ± 5.46
Duration of diabetes (years)	9.2 ± 7.04
Family history of diabetes (%)	29.5
Blood glucose (mmol/l, last measurement)	8.86 ± 3.03
HbA1c (%, last measurement)	7.72 ± 1.66
Diet treatment (%)	85.8
Diabetes-related drugs prescribed (%)	93.0

Expenditures for hospital care were estimated by multiplying the reported number of hospital days by the average regional cost per in-patient day spent on the general ward of a public hospital.[12] Public subsidies to the hospitals were added.

Expenditures for in-patient surgical interventions were calculated by multiplying the number of operations with the charges for the respective surgery.[10] The corresponding hospital days were accounted for as indicated above. Costs of haemodialysis were calculated from data provided by the Swiss Association for Common Issues in Health Insurance.[13]

Costs of medication

All prescribed medications with a direct or indirect relation to diabetes were recorded by name and daily dosage if taken regularly or continuously. The yearly dosage of every medication was calculated and finally multiplied by its unit price, using 1999 public prescription prices.[14] Non-prescription-based out-of-pocket expenses were not assessed.

Attributable risks

The cost figures resulting from the described procedure are costs of type 2 diabetes and its complications including macrovascular disease, but not all costs of macrovascular disease are diabetes related. The same is true for cataract and cataract surgery. Corrected cost figures were modelled by applying literature-derived diabetes-attributable risks to the costs of CABG surgery and PTCA, to the inpatient costs of patients with macrovascular disease, to the costs of cardiovascular drugs, and to the costs of cataract surgery.[15,16] If macrovascular and microvascular disease were present, it was assumed that only half of the hospital days reported were due to the former. Costs of physician consultations were not corrected, as the share of consultations due to macrovascular disease could not be to judged. Lipid tests were not corrected, as they were assumed to be necessary in all type 2 diabetes patients.

Statistical analysis

Non-stratified and stratified descriptive analyses were performed using SPSS version 10.0®.

RESULTS

A total of 111 physicians from 19 cantons throughout Switzerland participated and provided data on a total of 1479 patients who were currently being treated for type 2 diabetes. Two-thirds (66%) of the patients were seen by a general practitioner, 27% were seen by a doctor without specialization, and 7% by a non-subspecialized internist. On average every physician reported data on 13.2 patients (median 15 patients). Overall reporting quality was good, with less than 5% missing values in nearly all variables relevant for cost analysis.

Patient population

The 1479 patients analysed represent a sample of about 0.6% of all Swiss patients with type 2 diabetes. Demographic data are shown in *table 1* which shows that 83% (1226) of the patients came from the German speaking part of Switzerland, 16% (239) from the French speaking part, and 1% (14) from the Italian speaking part.

The following labour force participation rates were recorded: full-time employment 26.5%, part-time employment 3.7%, self-employed 7%, not employed 16.9%, jobless 1%, pensioners 38.6%, disability pensioners 6.2%.

Information on insurance status was available from 1041 patients. 81% of these patients had basic statutory insurance coverage only, 19% had a supplementary insurance package.

Type of treatment was distributed as follows: no specific treatment for diabetes was reported in 1.2% (17) of the patients; dietary treatment only was reported in 14.1% (208); while 60.1%

(887) had oral antidiabetic drugs. Insulin was used by 24.6% (364), in part combined with oral antidiabetic agents.
Diabetes-related complications were present in 56% of patients (*table 2*). Macrovascular complications (excluding hypertension) were present in 27%. Acute myocardial infarction and stroke affected 2.6% and 2.3% during the last year. Microvascular complications were recorded in 43%, neuropathy (including diabetic foot syndrome) in 23%, nephropathy (including microalbuminuria and proteinuria) in 28%, and eye complications in 13%. Amputations during the last year were reported in 1.6% of cases. As many as 15% of patients were affected by both macrovascular and microvascular complications.

Resource use
Mean annual medical resource utilization of patients with type 2 diabetes is shown in *table 3*. On average, patients had 10.3 diabetes-related physician consultations per year (95% CI: 10.0–10.7). In 15.4%, there was at least one hospitalization during the previous year which was due to diabetes or a diabetes-related complication. On average these persons spent 17.8 days in hospital (95% CI: 15.2–20.4), which results in a mean of 2.7 days (95% CI: 2.2–3.3) for the whole study population. Only every second patient had an ophtalmological control during the observation period. Apart from blood glucose measurements, HbA1c measurements were the most frequently performed laboratory tests.

Costs
Important direct cost factors are summarized in *table 4*. Mean annual direct medical costs of type 2 diabetes and its complications amounted to CHF 3,508 (95% CI: CHF 3,140–3,876) per year. Hospitalization costs, being the largest cost factor by far, contributed 53% of these costs. Medication costs contributed 30%. Ambulatory costs, comprising consultations, outpatient diagnostic and invasive procedures, and home care services by nurses, accounted for 17%.
The cost distribution of diabetes-related medication is characterized by a dominance of cardiovascular drugs over antidiabetic agents. The shares of oral antidiabetic drugs and insulin in the total medication costs were 24.7% and 17.3% (42% in total). The share of cardiovascular medications and lipid-lowering drugs was 39.4% and 9.2% (48.6% in total). Antibiotics used for the

Table 2 Complication frequencies of study population

	Frequency	
Type of complication	N	%
Coronary heart disease	312 / 1473	21.2
Peripheral arterial insufficiency	157 / 1473	10.7
Macrovascular complications (≥1)	393 / 1473	26.7
Neuropathy	342 / 1461	23.4
Nephropathy (incl. microalbuminuria and proteinuria)	365 / 1315	27.8
Retinopathy	188 / 1424	13.2
Microvascular complications (≥1)	619 / 1447	42.8
Any complication	816 / 1456	56.0
Both types of complications	215 / 1443	14.9
Myocardial infarction during the last year	39 / 1473	2.6
Stroke during the last year	34 / 1473	2.3
Amputation during the last year	23 / 1473	1.6

Table 3 Annual medical resource utilisation in patients with type 2 diabetes (N=1479)

	Frequency/patient/year	
Resource	Mean	95% CI
Physician visits	10.3	10.0–10.7
Ophthalmological controls	0.55	0.51–0.59
Laboratory tests	11.83	11.48–12.18
Plasma glucose	5.81	5.58–6.04
HbA1c	2.02	1.92–2.11
Serum creatinine	1.28	1.20–1.37
Cholesterol	1.05	0.99–1.11
HDL cholesterol	0.71	0.66–0.76
Triglycerides	0.80	0.74–0.85
Urine albumin (24 h)	0.17	0.13–0.20
Prescribed nurse visits	1.29	0.50–2.09
Computer tomographies	0.033	0.02–0.05
MRI	0.011	0.005–0.02
Hospitalizations	0.22	0.18–0.25
Hospital days	2.74	2.22–3.25
Peripheral dilatations	0.014	0.008–0.02
PTCA	0.0095	0.005–0.015

Table 4 Mean type 2 diabetes-related costs (direct, indirect and total) per year per patient in CHF and € (N=1479)

	Mean costs		95% CI		Attributable risk corrected costs	
Cost category	CHF	€ [a]	CHF	€ [a]	CHF	€ [a]
Direct medical costs	3,508	2,323	3,140–3,876	2,080–2,567	3,004	1,990
Drug costs	1,059	701	1,010–1,108	669–734	889	589
Ambulatory costs	592	392	559–625	370–414	558	370
Consultations [b]	295	195	282–308	176–191	295	195
Outpatient diagnostic procedures [c]	26	17	19–34	13–23	26	17
Outpatient invasive procedures [d]	98	65	73–123	48–81	65	43
Laboratory tests	172	114	166–178	110–118	172	114
Hospital care	1,856	1,229	1,509–2,203	999–1,459	1,557	1,031

a: Exchange rate: CHF 1 = € 0.6623 (11.12.2000).
b: Including outpatient nursing services.
c: X-rays, Doppler sonography, computer tomography, and magnetic resonance imaging.
d: Vitrectomy, laser therapy, and cataract extraction.

treatment of diabetic foot syndromes accounted for 0.5% of the total, and all other medications for 7.6%.

Table 5 shows direct medical costs stratified by treatment type and by the presence of complications. Diet-treated patients cost about 1.6 times more than the few untreated patients in our sample. The costs of diet-treated patients and of patients treated with oral antidiabetic drugs were nearly identical. Compared to these groups, insulin-treated patients were twice as expensive. Cost differences according to complication status were even more distinct. Patients with at least one microvascular complication cost nearly twice as much as patients without complications. Patients with at least one macrovascular complication (excluding hypertension) cost nearly three times as much, and persons with both types of complications more than four times as much. Within the group of patients with microvascular complications, isolated retinopathy was associated with particularly high costs. The same was true for isolated cerebrovascular disease within the group of patients with macrovascular complications. The character of these findings remained unchanged after further stratifying by both treatment type and complication status, by quartiles of the duration of diabetes, and by quartiles of the last measured HbA1c value (data not shown.)

Cost correction for adjuvant materials

The utilization of glucose monitoring strips was estimated at CHF 15 per month. Glucose monitoring devices were assumed to be exchanged every two years. The mean costs of all other adjuvant materials were estimated to be CHF 0.50 per day in those using insulin. These assumptions lead to an estimate of the costs of adjuvant materials of CHF 320 (€ 212) per year.

Cost correction by application of attributable risks

Available evidence allows for the assumption that the relative risk of coronary heart disease in persons with diabetes is in the range of 2.5.[17–21] This corresponds to an attributable risk of 0.6. The relative risk of stroke can be assumed to be 4, with an attributable risk of 0.75.[22–24] Studies on cataract indicated an odds ratio of cataract surgery in persons with compared to persons without diabetes of 1.8 to 2.5. If the rare disease assumption is made, the corresponding relative risk can be estimated to be in the range of 2, and the attributable risk to be in the range of 0.5.[25–27] Application to the cost results of this analysis reduces mean inpatient costs to CHF 1,557, mean costs of consultations and outpatient services to CHF 262, mean medication costs to CHF 889, and mean direct costs to CHF 3,004 (*table 4*). The relative size of the different cost factors is hardly affected.

Applying both the attributable risk correction and the correction for the adjuvant materials changes the primary cost estimate to CHF 3,324 (€ 2,201).

Total healthcare expenditures for type 2 diabetes in Switzerland

Studies to determine the exact prevalence of type 2 diabetes in Switzerland have not been published. According to an estimate of the Swiss Diabetes Association there are 250,000 patients with type 2 diabetes in Switzerland. Combining this number with the cost figure of CHF 3,508 leads to an estimate of the total 1998 costs of type 2 diabetes and its complications of CHF 0.88 billion, which represents a share of 2.2% of total healthcare expenditures in Switzerland. If the corrected cost figure of CHF 3,324 is used, total costs at this level are CHF 0.83 billion or 2.1% of total healthcare expenditures in Switzerland.

DISCUSSION

Bias and cost measurement issues have to be addressed. Participation was restricted to physicians treating a minimum of 10 persons with diabetes. At least in part, this explains the low nominal participation rate of 3.6% of the physicians invited. Still, it cannot be ruled out that some selection bias was introduced at this level, affecting the ability to generalize the results, but there is no obvious reason to assume a link between physician participation and resource use. Also, some doctors could have chosen not to include their most problematic and expensive cases, which would have resulted in an underestimation of costs. Nevertheless, the representativeness of our sample is supported by the patient characteristics observed (*table 1*), which are well in the range to be expected from other European studies referring to patients with a known history of type 2 diabetes.[28–30]

An abstract referring to an epidemiological cross-sectional CODE-2 substudy conducted in Germany reports, among other data, cardiovascular complications in 43% of patients, neuropathy in 23%, and ophthalmological complications in 11%.[31] Cardiovascular complications were observed in 23% of

Table 5 Mean type 2 diabetes-related direct costs per year per patient in CHF and €, by treatment type and by complication status

	N	Mean CHF	Mean € [a]	95% CI CHF	95% CI € [a]	Relation to mean direct costs
Treatment group						
No treatment	17	1,732	1,147	308–3,156	204–2,090	0.49
Diet only	208	2,822	1,869	1,841–3,804	1,219–2,519	0.80
Oral antidiabetics	887	2,776	1,839	2,422–3,130	1,604–2,073	0.79
Insulin treatment	364	5,779	3,827	4,729–6,839	3,132–4,529	1.65
Complication status						
No complications	640	1,723	1,141	1,477–1,970	978–1,304	0.49
Microvascular	419	3,205	2,123	2,704–3,706	1,791–2,454	0.91
Nephropathy [b]	153	2,009	1,331	1,554–2,465	1,029–1,633	0.57
Neuropathy [b]	77	2,199	1,370	1,494–2,903	931–1,809	0.63
Retinopathy [b]	36	3,893	2,425	2,189–5,598	1,364–3,488	1.11
Macrovascular	170	5,050	3,345	3,901–6,198	2,584–4,105	1.44
Cardiovascular [b]	114	4,394	2,737	3,124–5,664	1,946–3,529	1.25
Cerebrovascular [b]	7	11,042	6,879	0–22,850	0–14,236	3.15
Peripheral [b]	23	3,601	2,243	1,358–5,843	846–8,869	1.03
Micro- and macrovascular	215	8,475	5,613	6,598–10,351	4,370–6,855	2.42

a: Exchange rate: CHF 1 = € 0.6623 (11.12.2000).
b: Persons with isolated occurrence of the named complication. No other complication.

patients only, but similar shares of patients with microvascular complications. Part of this discrepancy may arise from different definitions, e.g. a possible inclusion of hypertension in the definition of CHD in the CODE-2 substudy. Another part may be due to the fact that our questionnaire explicitly referred to a time interval of 12 months. This may have caused an under-reporting of CHD in patients who were not affected by a CHD-related event during the observation period.

Our method of cost measurement reflects the availability of data in Switzerland. Many cost-of-illness studies in the field of diabetes used 'top-down' approaches, particularly in the USA.[15,32] They were based on national aggregate databases and on general population surveys of health, healthcare, disability, and mortality. In Switzerland, only very few healthcare data are available on an aggregate level. 'Bottom-up' studies are an accepted alternative in this kind of situation, albeit they are subjected to the risks of extrapolation if statements at the population level are required. In general terms, they allow for more precise cost estimates, as individual utilization patterns are observed directly rather than estimated from aggregate data. On the other hand they tend to be conservative, the main reason being the near-impossibility to measure all potentially relevant consumptions of resources.

In particular, three facts hint at a certain underestimation of the true costs of type 2 diabetes and its complications in this study: 1) physicians may not have had a complete overview of all resource utilizations of their diabetic patients. They may not have learned of some consultations of specialized physicians, and they surely did not record out-of-pocket expenses. Also, physicians' charts do not document all cost-inducing details of, for example, patients' inpatient episodes. 2) Services provided by physiotherapists or dieticians and the costs of long-time hospice care could not be taken into account in our calculations. The costs of adjuvant materials such as glucose monitoring devices and strips could only be estimated. 3) The exclusion of incident and dying cases implies a certain underestimation of costs and a potential limitation of the generalizability of our results to all Swiss patients with type 2 diabetes. However, the results of Brown *et al.*, referring to the costs of US patients with type 2 diabetes during the first eight years after diagnosis, support the expectation that the underestimation induced is relatively small.

Showing the costs of patients with different kinds of isolated diabetic complications (*table* 5) is illustrative but may, to a certain extent, be misleading. Persons with additional conditions may have different costs with respect to the complication in question. On the other hand, if all persons with this complication are considered, unregarding the presence of other conditions, its relative contribution remains again unclear.

A major point to discuss is the assessment of the costs of diabetes complications in general. The question of the share of diabetes is easily answered with respect to microvascular disease, but not regarding macrovascular disease which is present in the general population as well. Some US studies used epidemiological population-attributable risk formulas to assess the diabetes-related costs of macrovascular disease, but, due to the lack of large databases, reliable attributable risk figures are difficult to generate in Switzerland.[5,33] Other studies, like CODE-2, measured total healthcare costs of persons with type 2 diabetes, but the resulting figures are of limited use without a control group.[1,28] Including an adequate control group would have been beyond the scope and possibilities of this study. Therefore, diabetes-related costs were measured, and complication costs were included in total. In a second step, literature-derived relative risks were used to estimate the diabetes attributable risks (at the patient level) of macrovascular disease and cataract.[15,16] Using these, corrected costs were calculated. These can be viewed as a broad estimate of the costs of type 2 diabetes itself.

Table 6 Examples of cost of illness studies in the field of diabetes

	Reference					
Parameter	Rubin *et al.* 1994[4]	American Diabetes Association 1998[5]	Brown *et al.* 1999[34]	Henrikkson *et al.* 1998[30]	Detournay *et al.* 1999[36]	Jönsson 2002 (CODE-2)[28]
Country and year of reference	USA, 1992	USA, 1997	USA, 8 years from 1988–1995	Sweden, 1994	France, 1998	Eight European countries, 1999
Patient group	Non-institutionalized patients with diabetes	Patients with diabetes	Incident patients with type 2 diabetes	Patients with diabetes	Patients with type 2 diabetes	Patients with type 2 diabetes
Top-down or bottom-up	Bottom-up	Bottom-up	Bottom-up	Top-down	Review	Bottom-up
Costs measured or assessed	Total direct healthcare costs of persons with diabetes	Costs of diabetes and attributable complication costs	Total direct healthcare costs of persons with diabetes	Costs of diabetes and complication costs	Total direct healthcare costs of persons with diabetes	Total direct healthcare costs of persons with diabetes
Source and method of cost measurement	Survey data	Diagnostic category data, application of attributable risk procedures	HMO electronic medical record data	Administrative databases	Published materials	Medical records, patient questionnaires
Control group	Yes	Not applicable	Yes	Not applicable	Yes	No
Cost estimate	(Excess) costs of persons with diabetes	Costs of diabetes and its complications	(Excess) costs of persons with type 2 diabetes, first 8 years from diagnosis	Costs of diabetes and its complications	Excess costs of persons with type 2 diabetes	(Total direct) costs of persons with diabetes
Direct medical costs per person-year	Excess US-$ 6,889 = € 7,769[a]	US-$ 2,600 = € 2,923[a]	US-$ 2,257 = € 2,545	SEK 18,600 = € 2,165[a]	FF 10,000 = € 1,524[a]	€ 2,834

a: Direct medical costs per person-year calculated from the reference paper. Exchange rates: US-$ 1 = € 1.12780, SEK 1 = € 0.11640, 1 FF = € 0.15240 (11.12.2000).

The characteristics of some important reference studies on the cost of diabetes are summarized in *table* 6. US studies tend to report higher costs than European studies.[4,5,15,33] This can in part be explained by differential characteristics of the US and European healthcare and accounting systems, by methodological differences, and by the way of presentation. The American Diabetes Association (ADA) reported US costs attributable to type 1 and type 2 diabetes in 1997 of US-$ 98.2 billion.[5] As in our case, costs were calculated on the basis of a 'bottom-up' approach and of attributable risk procedures, but the assessment of resource utilisation was more comprehensive.[15] Reported direct medical costs of $ 44.1 billion equal 4.5% of the total US healthcare expenditures in 1997, comprising the costs of diabetes itself and its chronic complications, as well as the costs of an excess prevalence of general medical conditions observed in diabetes patients, which we didn't measure. Thus, the figure to directly compare our results with is US-$ 19.5 billion only, corresponding to US-$ 2600 per patient with diabetes (according to the prevalence estimate of 3% used in the ADA study), and to 2% of the total 1997 US healthcare expenditures. Obviously these results are well in the same range as ours, especially in relative terms and regarding the fact that the presumably higher costs of type 1 diabetes are included here.

Another frequently cited study is the one by Rubin *et al.*, which estimated that persons with type 1 or type 2 diabetes accounted for 14.6% of total US healthcare expenditures in 1992.[4] This figure refers to the total healthcare expenditures caused by persons with diabetes, and not to diabetes-related costs only. Also, it is based on a prevalence estimate of 4.5% which is derived from broad inclusion criteria on the basis of self-reporting. With these facts in mind the difference between the results of Rubin and colleagues and our own estimates looses its out-of-range quality.

Brown *et al.* conducted an analysis of electronic HMO patient records, assessing the costs of patients with type 2 diabetes during the first eight years after diagnosis.[34] They reported yearly excess costs of US-$ 2,257 (€ 2,545) compared to matched nondiabetic patients. Their variation over the period observed was small.

Only few single-country cost of illness studies of diabetes have been performed in Europe. Two studies conducted in the UK and Sweden both used a 'top down approach' relying on public registries.[30,35] The latter reported 1994 costs of about SEK 18,600 (€ 2,000) per person-year. A 1998 French review yielded excess costs of persons with type 2 diabetes of FF 10,000 (€ 1,524).[36] The Costs of Diabetes in Europe – Type 2 (CODE-2) study was conducted in eight European countries and, similar to Rubin *et al.*, measured direct healthcare expenditures for people with diabetes instead of diabetes-related expenditures only.[28] Thus, somewhat higher cost results than ours are expected. In fact, CODE-2 calculated mean direct *per capita* healthcare expenditures of € 2,834 per person-year.[28]

Overall, the results reported in the international literature correspond well with our corrected estimate of CHF 3,324 (€ 2,201).

Our findings that in-patient costs account for the largest single share of direct medical expenditures related to diabetes and that complication status strongly influences *per capita* costs is confirmed by virtually all international studies.[4,5,15,33,37]

The results from CODE-2 are in line with many of our more detailed observations. They confirm that the presence of complications is responsible for an impressing increase in *per capita* costs.[28,38] This is particularly true if macro- and microvascular complications are present at the same time.[29] In CODE-2 as in our study, hospitalizations are the most important single factor contributing to the direct costs of type 2 diabetes.[28] They represent a share of 30–65% of the total direct costs in the CODE-2 countries, compared to 52.9% in Switzerland. Oral antidiabetic drugs account for a proportion of 2–7% in CODE-2 and for 7.4% in the study presented here. Our observation of a dependence of direct costs on treatment type is also mirrored in CODE-2.[38]

The observation that the costs of diet-treated patients and of patients treated with oral antidiabetic drugs were nearly identical results from distinctly higher inpatient costs in the former group. The difference observed, though, is far from statistical significance (p=0.55). An artefact may be the most likely explanation. Both groups were similar in many respects, and no conclusive differences favouring the drug-treated group were seen in the number of hospitalisations or the share of complications and revascularization procedures. Outliers were neither playing an important role.

In Switzerland, as in other countries, type 2 diabetes is a disease which not only has an important medical but also an enormous economic impact. It is a challenge for the Swiss as well as any other healthcare system to allocate resources for the prevention of type 2 diabetes and its complications instead of simply accepting very high treatment costs for these conditions. Our results confirm this despite their conservative nature. Future studies will have to refine our assessment of direct and especially indirect costs, to get the full picture into view.

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