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The economic burden of diabetic retinopathy in Germany in 2002

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Abstract
Background The aims of our study were to describe the costs associated with diabetic retinopathy (DR), and to evaluate its economic impact in Germany.
Methods Forty-one German ophthalmologists, randomly selected from a physicians' database in Germany, provided information on adult Type 1 and Type 2 diabetic patients with DR (n=207). This information included socio-demographics, clinical characteristics and resource use during the year 2002. National-level cost estimates were calculated, based on these results and the prevalence data on DR in Germany.
Results This study found that costs associated with DR tend to increase as DR progresses, being highest in patients with proliferative DR and lowest in patients with mild, non-proliferative DR. The German statutory health insurance (Gesetzliche Krankenversicherung, GKV) covered two-thirds of the total costs paid by all the payers. The total cost of DR from a societal perspective was calculated at €3.51 bn for the year 2002, and from the GKV perspective amounted to €2.23 bn.
Conclusions This study is the first comprehensive study to provide estimates of costs associated with DR in Germany. These costs were estimated to account for approximately 1.5% of the total health-care expenditure in 2002.

Keywords Diabetes · Type 1 diabetes · Type 2 diabetes · Retinopathy · Costs

Abbreviations

DM	diabetes mellitus
NPDR	non-proliferative diabetic retinopathy
SNPDR	severe non-proliferative diabetic retinopathy
PDR	proliferative diabetic retinopathy
ME	macular edema
GKV	Gesetzliche Krankenversicherung (statutory health insurance)

Introduction

Diabetic retinopathy (DR), one of the major, long-term microvascular complications of diabetes mellitus (DM), is the leading cause of blindness in Germany [1]. Initially, most people with DR experience only mild vision problems. Visual loss in diabetic patients is often a late symptom of advanced retinopathy; therefore, severe retinal damage caused by DM may remain undiagnosed. It has been estimated that about 10% of people after 15 years of DM will develop severe visual handicap [2]. Visual impairment related to DR may have serious consequences in diabetic patients, profoundly affecting health- and vision-related quality of life and leading to difficulties in treatment and non-compliance resulting from reduced ability of patients to manage their disease. Progression of DR has

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been reported to impact the health-related quality of life [3], which not only affects patients both physically and emotionally, but carries a significant economic burden for the diabetic patient and family members, society and the health-care system.

The total financial cost of visual disorder due to DR among US residents aged 40 years or older in 2004 was estimated at US$493 million and average annual total cost per DR patient was about US$629 [4]. About US$9 bn are annually spent in Canada—which includes both direct and indirect costs of DM [5, 6]—while mean annual treatment costs per patient in 2000 were Can$379 for proliferative DR, Can$423 for macular edema, and Can$495 when both conditions were present [6].

In Germany, the economic burden of diabetes was estimated at €5.7 bn for the year 1999, which included both direct and indirect costs [7]. Total yearly direct mean costs per patient with type II DM in Germany for the same year were estimated at €3,576, which was about 2.7 times higher than Spain and was the highest estimate reported across eight European countries according to the CODE-2 Study [8]. In 2001, annual direct mean costs per patient with DM were €5,262, and indirect costs were €5,019 [9]. About €100 million are provided yearly as pensions to visually impaired people with DM in Germany [10]. Diabetes-related costs are estimated to account for 6.80% of total health-care costs in Germany, based on the published results from the CoDiM Study [9]. Yet information on the cost burden of DR in Germany is still lacking. It is needed so that decision makers may make informed decisions about the management of DR and have a clearer picture of the economic implications of DR on society.

The objectives of this study were to describe the costs associated with diabetic retinopathy and to evaluate its economic impact in Germany.

Patients and methods

This non-interventional, cross-sectional study was carried out in Germany in 2003. The study collected information on costs attributed to DR, retrospectively, by means of questionnaires and medical charts. Overall, 41 ophthalmologists (n=41 ophthalmologic practices) participated in the study, who had been randomly selected from a German physicians' database [11]. Response rate was high, about 82%; none of the physicians dropped out from the study. Eight centers (19.5%) were selected from East Germany and 33 centers (80.5%) from West Germany, and the centers were from almost all regions of Germany (with exception of Bremen and Schleswig-Holstein), thus ensuring a representative distribution of ophthalmologists in the study sample. Severity classes of retinopathy were based on the International Clinical Classification for Diabetic Retinopathy, developed in 2002 [12]. This classification was modified for this study to include macular edema (ME) as an additional class. All patients were separated into five mutually exclusive groups according to their degree of DR and presence of ME as follows: Group 1—mild non-proliferative diabetic retinopathy (NPDR) without ME, Group 2—moderate NPDR without ME, Group 3—severe NPDR without ME, Group 4—proliferative diabetic retinopathy (PDR) without ME, and Group 5—patients with ME and any degree of diabetic retinopathy. The severity of DR in the worst affected eye was used for retinopathy grading. Each ophthalmologist was given a randomly assigned combination of five retinopathy stages at the beginning of this study to consecutively recruit one patient with DR for each of these stages. On average, each ophthalmologist recruited five patients, and a very small number of physicians recruited more than five—using the assigned combination of DR stages one more time. The numbers of patients in five strata were approximately the same. It was assumed that the annual resource use with respect to the stage of retinopathy is comparable in Type 1 and 2 DM patients; therefore, the selection of patients participating in the study is independent of the type of diabetes.

The inclusion criteria for the study were as follows: (1) men and women aged 18 years or older, (2) with Type 1 or 2 DM, (3) DR diagnosed on or before 2 January 2002 and treated in the year 2002, and (4) willing and able to give written informed consent. Exclusion criteria were pregnancy or participation in a clinical trial in the year 2002. The study was performed in accordance with the Declaration of Helsinki (1996) and local ethics requirements, and was approved by the German regulatory authorities. All patients who were approached agreed to participate in the study, and none of them dropped out from the study.

Patient demographic and medical data, data on concomitant diabetes-related diseases and resource utilization in the year 2002 were extracted from the medical charts. Since not all resource-use data are recorded in patients' charts, patient interviews to retrieve additional resource use data were undertaken.

Costs

The costs (euro, 2002 values) were estimated for each patient for a period of 1 year. The cost analysis addressed only resources related to DR. Costing for all patients was done from the societal perspective and the perspective of the statutory health insurance (GKV).

The medical costs included inpatient and outpatient charges. Patient expenses for co-payments were also included. Inpatient costs included rehabilitation, medical

and surgical facilities. The categories of outpatient costs included primary care visits, specialist visits, ambulatory surgical facility, diagnostics, laboratory analyses, durable medical equipment, skilled nursing facilities and all other non-drug therapies, medical and surgical supplies. Rehabilitation and therapy costs were based on survey data. Durable medical equipment and supplies were based on manufacturers' price lists. All other outpatient costs (such as physician visits, diagnostics and laboratory costs) were derived using the uniform value scale [13] (EBM, Einheitlicher Bewertungsmaßstab) of the German health insurance system (by multiplying the corresponding point values of a service or procedure by €0.0511/point value [14]).

Pharmaceutical costs included all relevant medications for DR treatment paid for by the insurance company and the patients. Medication costs were taken from the "Rote Liste 2002" (the German Formulary) [15]. If the brand name of the medication was not given and only the active ingredients of the drug were specified, the most frequently prescribed drug, including the ingredients according to Pharmaceutical Prescriptions Report 2002 ("Arzneiverordnungsreport 2002"), [16] was assumed. Daily drug costs were multiplied by the number of days on therapy. For the pharmaceutical costs estimation from the GKV perspective, pharmacy discount of 5% [17] as well as patient co-payment were subtracted. Co-payments paid by patients with DR are not only related to pharmaceuticals, but also apply to daily fees for hospital stays, rehabilitative care (€8.69/day [18]), visual aids (reading glasses, magnifiers, pocket-lamps), orientation and mobility aids (canes) or other relevant devices.

Home health care and transportation to a health-care provider were used as a basis for the calculation of direct non-medical costs.

The indirect costs, such as costs due to sick leave, disability, blindness allowances and early retirement because of DR, were also assessed. Temporary inability to work is relevant from both societal and GKV perspectives. To assess the economic costs of early retirement, average early retirement pensions per month were multiplied by the duration of early retirement. Costs resulting from temporary disability were assessed from the societal perspective using the mean gross wage of employees, according to the German Federal Statistical Office [19] (€150/day in 2002). Total costs were derived by multiplying the number of days with inability to work by the daily costs. Daily costs were 121% of the daily, before-tax wage (wage continuation plus 21% ancillary wage costs) until Day 42 of the inability to work. As of Day 43, 100% of the daily net wage was used (90% of the daily net wage [sick pay] plus 10% of daily net wage [patient's loss of income]). Costs due to temporary disability from the GKV perspective were assessed based on 90% of the daily net wage paid after Day 42. All calculations were performed using the SAS Software (Version 8.2; SAS Institute Inc., Cary, NC, US).

Results

The demographic and clinical characteristics of the study population (n=207 patients) are shown (Table 1). The majority of patients (weighted percentage 74.4%) had Type 2 diabetes. Of the 207 patients with DR, 44 (21.3%) had mild NPDR, 48 (23.2%) moderate NPDR, 52 (25.1%) severe NPDR, and 63 (30.4%) PDR. Forty-six (22.2%) patients had ME; one of these patients (2.2%) had mild NPDR, seven patients (15.2%) moderate NPDR, 14 patients (30.4%) severe NPDR, and 24 patients (52.2%) PDR. Of the 46 patients with ME, 40 (87.0%) had a clinically significant ME. About three-quarters (weighted percentage 73.4%, 148/207) of all patients were married or co-habiting, and the vast majority of patients lived with a partner or family member (weighted percentage 68.7%, 144/207). About half of all patients never smoked (weighted percentage 55.9%, 120/207). Only nine patients (out of 207) were covered by private health insurance; the others had the GKV coverage. A quarter of all patients (weighted percentage 25.2%, 50/207) were employed in 2002; the main reasons for patients' non-employment included retirement (weighted percentage 61.7%, 95/157) and early retirement (weighted percentage 16.3%, 26/157).

Resource use

On average, patients visited their ophthalmologists about five times in 2002. There was a tendency in number of outpatient visits to an ophthalmologist to rise with increasing severity stage of the DR (p=0.0001, by analysis of variance) (see Table 2). Basic routine examinations, such as funduscopy tests for visual acuity assessment, and measurement of intraocular pressure were similar across the different stages of retinopathy. Fluorescein angiography (p=0.0041), laser panretinal (p=0.0061) or focal photocoagulation (p=0.0058) treatments were less frequently performed in patients having mild NPDR (by χ^2 test). About half of the patients also had other physician visits during the year 2002. Patients visited their general practitioners twice on average and their internists or diabetologists once in that year. The mean total number of visits at physician sites, other than ophthalmologic offices, was about four per patient in the year 2002. Three accidents (weighted percentage 2.2%, 3/207) requiring ambulatory treatment were attributable to the poor vision due to DR: two patients were involved in pedestrian accidents and one was injured at home—all three patients had ME.

Table 1 Description of the study population (n=207)*

Demographic characteristics	Group 1 (n=43)	Group 2 (n=41)	Group 3 (n=38)	Group 4 (n=39)	Group 5 (n=46)
Age, years (mean, SD, range)	60 (15) 19–86	65 (12) 31–93	62 (12) 33–82	60 (14) 32–88	63 (13) 29–85
Gender (n, % females)	19 (44.2%)	19 (46.3%)	20 (52.6%)	20 (51.3%)	26 (56.5%)
BMI (kg/m2)	28.2 (4.6)	28.0 (4.8)	26.9 (4.0)	28.8 (4.6)	27.6 (4.0)
Time since diagnosis of diabetes (years)	19 (10)	19 (11)	20 (9)	22 (11)	19 (10)
Time since diagnosis of any form of diabetic retinopathy, years (median, range)	5 (1–72)	5 (1–34)	8 (0–39)	7 (1–52)	9 (1–31)
Smoking status in 2002 (n, %)					
Currently a smoker	10 (23.3%)	11 (26.8%)	7 (18.4%)	11 (28.2%)	5 (10.8%)
Ex-smoker	12 (27.9%)	6 (14.6%)	9 (23.7%)	2 (5.1%)	13 (28.3%)
Never smoked	21 (48.8%)	24 (58.5%)	22 (57.9%)	25 (64.1%)	28 (60.9%)
Employed in 2002 (n, %)	13 (30.2%)	9 (22.0%)	12 (31.6%)	6 (15.4%)	10 (21.7%)
Covered by statutory health insurance (n, %)	42 (97.7%)	39 (95.1%)	35 (92.1%)	38 (97.4%)	44 (95.7%)
Clinical characteristics					
Type of diabetes (n, %)					
Type 1	12 (27.9%)	11 (26.8%)	9 (23.7%)	12 (30.8%)	10 (21.7%)
Type 2	31 (72.1%)	30 (73.2%)	29 (76.3%)	27 (69.2%)	36 (78.3%)
Treatment type (n, %)					
Diet	21 (48.8%)	22 (53.7%)	17 (44.7%)	19 (48.7%)	20 (43.5%)
Oral glucose-lowering drugs	24 (55.8%)	26 (63.4%)	18 (47.4%)	18 (46.2%)	25 (54.4%)
Insulin alone or in combination	31 (72.1%)	31 (75.6%)	33 (86.8%)	35 (89.7%)	40 (87.0%)
Laser coagulation therapy in 2002 (yes, n, %)					
Focal only	3 (7.0%)	6 (14.6%)	8 (21.1%)	10 (25.6%)	9 (19.6%)
Panretinal only	2 (4.7%)	5 (12.2%)	1 (2.6%)	4 (10.3%)	7 (15.2%)
Both	0	1 (2.4%)	3 (7.9%)	3 (7.7%)	8 (17.4%)
Fluorescence angiography in 2002 (yes, n, %)	3 (7.0%)	7 (17.5%)	7 (18.4%)	7 (17.9%)	18 (39.1%)
Blood glucose HbA_1c (%)	7.1 (1.1)	7.4 (0.9)	7.6 (1.5)	7.3 (1.2)	7.5 (1.5)
Progressive retinopathy in 2002 (n, %)	7 (16.3%)	12 (29.3%)	16 (42.1%)	15 (38.5%)	33 (71.7%)
Impaired vision (n, %)	17 (39.5%)	26 (63.4%)	32 (84.2%)	34 (87.2%)	46 (100%)
Legally blind** in 2002 (n, %)	0	1 (2.4%)	1 (2.6%)	2 (5.1%)	3 (6.5%)
Best-corrected visual acuity, binocular	0.92 (0.2)	0.84 (0.2)	0.73 (0.3)	0.60 (0.3)	0.38 (0.3)
Symptoms of diabetic retinopathy					
Floaters (n, %)	14 (32.6%)	12 (29.3%)	11 (29.0%)	17 (43.6%)	22 (47.8%)
Dark streaks or red film that blocks vision (n, %)	1 (2.3%)	2 (4.9%)	5 (13.2%)	16 (41.0%)	10 (21.7%)
Blurred vision (n, %)	17 (39.5%)	18 (43.9%)	28 (73.7%)	22 (56.4%)	35 (76.1%)
Distortion of lines (n, %)	3 (7.0%)	6 (14.6%)	5 (13.2%)	9 (23.1%)	22 (47.8%)
Flashing lights (n, %)	1 (2.3%)	1 (2.4%)	4 (10.5%)	1 (2.6%)	7 (15.2%)
Difficulty adjusting from bright light to dim light (n, %)	14 (32.6%)	11 (26.8%)	12 (31.6%)	16 (41.0%)	23 (50.0%)
Color vision abnormalities (n, %)	2 (4.7%)	0	2 (5.3%)	8 (20.5%)	8 (17.4%)

*Mean and SD are shown unless otherwise specified.
**Visual acuity in best-seeing eye 1/50 or less.
Percentages may not sum to 100% because of rounding.
SD=standard deviation, BMI=body mass index, n=number of patients.

When ranking the resources used by the percentage of patients who consumed these resources because of DR, medical devices (36.7% [95%CI: 30.1–43.3]) represented the most frequently used resource category, followed by transport (16.9% [95%CI: 11.8–22.0]) and medication (15.8% [95%CI: 10.8–20.8]). The medical resource usage almost doubled in the patients with ME compared with those with mild or moderate NPDR. Glasses (65.6% [95% CI: 54.9–76.3]) and magnifying glasses (27.1% [95%CI: 17.1–37.1]) were among the most frequently prescribed medical devices. Transport use increased with progression of DR (p=0.0002, by analysis of variance). Although transport by an emergency ambulance was seldom used, private cars and taxis were predominantly used for transportation of patients in this study. Medication consumption tended to be higher in patients with PDR and ME (p=0.0004, by χ^2 test). Nursing services were needed only for the patients with severe NPDR, PDR and ME. Family

Table 2 Resource consumption because of retinopathy, per year and group (Germany, 2002)*

Resources used	Group 1 (*n*=43)	Group 2 (*n*=41)	Group 3 (*n*=38)	Group 4 (*n*=39)	Group 5 (*n*=46)
Number of visits to ophthalmologist (mean, SD, range)	3.8 (3.7) 1–21	3.6 (2.3) 1–10	5.5 (3.3) 2–13	6.0 (4.1) 1–23	7.3 (6.0) 1–24
Number of visits to other physicians (GP, internists, diabetologists) (*n*, %)	17 (39.5%)	18 (43.9%)	13 (34.2%)	21 (53.9%)	25 (54.4%)
Number of visits to GP (mean, SD, range)	2.0 (3.9) 0–12	2.2 (3.6) 0–12	2.8 (9.0) 0–48	2.1 (3.5) 0–12	2.2 (3.7) 0–12
Number of visits to internist (mean, SD, range)	1.2 (3.8) 0–20	0.5 (1.8) 0–10	0.4 (2.0) 0–12	0.7 (2.2) 0–12	0.9 (2.7) 0–12
Number of visits to diabetologist (mean, SD, range)	0.5 (1.7) 0–10	0.8 (2.1) 0–8	0.2 (0.9) 0–4	2.4 (6.4) 0–36	0.7 (1.7) 0–8
Hospitalization (yes, *n*, %)	0	2 (4.9%)	2 (5.3%)	6 (15.4%)	8 (17.4%)
Number of hospitalizations per patient (mean, SD, range)	0	0.1 (0.2) 0–1	0.1 (0.2) 0–1	0.2 (0.5) 0–2	0.4 (0.8) 0–3
Rehabilitation (yes, *n*, %)	1 (2.3%)	0	1 (2.6%)	1 (2.6%)	0
Temporary working disability (yes, *n*, %)	1 (2.3%)	3 (7.3%)	4 (10.5%)	1 (2.6%)	5 (10.9%)
Early retirement (yes, *n*, %)	0	1 (2.4%)	1 (2.6%)	4 (10.3%)	2 (4.4%)
Medical devices (yes, *n*, %)	12 (27.9%)	11 (26.8%)	14 (36.8%)	14 (35.9%)	25 (54.3%)
Transport (yes, *n*, %)	3 (7.0%)	5 (12.2%)	7 (18.4%)	6 (15.4%)	14 (30.4%)
Medication (yes, *n*, %)	3 (7.0%)	1 (2.4%)	4 (10.5%)	12 (30.8%)	13 (28.3%)
Further non-drug therapy (yes, *n*, %)	0	0	0	1 (2.6%)	2 (4.4%)
Nursing services (yes, *n*, %)	0	0	3 (7.9%)	6 (15.4%)	6 (13.0%)
Home help services (yes, *n*, %)	0	1 (2.4%)	5 (13.2%)	7 (18.0%)	10 (21.7%)
Other services (yes, *n*, %)	1 (2.3%)	1 (2.4%)	1 (2.6%)	4 (10.3%)	8 (17.4%)

*Mean and SD are shown unless otherwise specified.
SD=standard deviation, n=number of patients.

members and friends of the patients were the main providers of nursing care. Further non-drug therapy (mainly psychotherapy and acupuncture) was used only in three patients and was therefore very rare, as was the use of rehabilitation facilities.

Costs of diabetic retinopathy

All costs attributable to DR were calculated from the societal perspective and GKV perspective. The DR was estimated to cost on average €1,433 [95%CI: 555–2,311] in 2002 from the societal perspective. The total costs were highest in patients with ME (Group 5) and lowest in patients with mild NPDR (Group 1) (see Table 3).

Medical devices and temporary working disability accounted for almost half of the costs of the DR from the societal perspective (Fig. 1). The remaining half of these costs was mainly composed of the following parts: other services (e.g. tax exemption, exemption from radio and phone fees, free public transportation, blindness allowances and costs for a guide dog), early retirement, hospitalization, and visits to ophthalmologists. Medication costs, visits to other physicians, transportation, non-drug therapy, home help, rehabilitation, and nursing care were the smallest components of the DR costs, and comprised about 8% of the total cost of DR per patient in 2002 from the societal perspective. The average cost of DR, from the GKV perspective, was €911 per patient in that year [95%CI: 395–1,426]. The cost of medical devices comprised about one third of the total costs of DR, followed by temporary working disability, hospitalization and visits to ophthalmologists. Medical devices and temporary working disability accounted for 58% of the total costs, hospitalization and visits to ophthalmologists comprised 30%, and the remaining 12% the combination of all other costs (Fig. 2). It is important to remember that the costs from the perspective of the GKV are not affected by the cost components resulting from home help services and temporary (up to 6 weeks) working disability.

The GKV covered two thirds of the total costs paid by all the payers, and is therefore the main payer of costs for DR (Fig. 3). Employers comprised another major category of payers. In Germany, employers are obliged to pay continuation of wage plus ancillary wage during the first 6 weeks of temporary working disability of their employees. Pension funds represented the third major payer, while patients and nursing insurance made the smallest financial contribution (Fig. 3).

Table 3 Total costs from the societal and the GKV perspectives, per DR group (mean costs per year and patient, Germany, 2002)

Costs* in €	Group 1 (n=43)	Group 2 (n=41)	Group 3 (n=38)	Group 4 (n=39)	Group 5 (n=46)	Total (range) (n=207)
Societal perspective						
Medical devices	130	126	180	156	766	343 (0–24,294)
Temporary working disability	22	13	191	2	932	328 (0–17,122)
Other services	5	15	176	38	536	192 (0–8,588)
Early retirement	0	216	233	681	289	181 (0–8,849)
Hospitalization	0	9	89	277	373	142 (0–5,065)
Ophthalmologists fee	45	81	120	144	249	128 (0–823)
Medication	15	9	7	47	59	29 (0–561)
Other physicians fee	9	18	107	17	32	24 (0–3,518)
Transport	5	5	22	10	51	21 (0–851)
Further non-drug therapy	0	0	0	209	23	17 (0–8,153)
Home help services	0	0	192	159	0	17 (0–7,300)
Rehabilitation	0	0	96	83	0	8 (0–3,638)
Nursing services	0	0	0	83	0	4 (0–2,460)
Total costs from the societal perspective (range) [95% CI]	231 (3–2,038) [119–343]	490 (3–8,980) [64–916]	1,411 (8–8,932) [655–2,168]	1,905 (8–12,343) [929–2,881]	3,311 (5–42,110) [1,283–5,339]	1,433 (3–42,110) [555–2,311]
GKV perspective						
Medical devices	130	126	180	156	766	343 (0–24,294)
Temporary working disability	0	0	0	0	600	198 (0–12,103)
Other services	0	0	0	0	37	12 (0–1,692)
Hospitalization	0	9	89	277	373	142 (0–5,065)
Ophthalmologists fee	45	81	120	144	249	128 (0–823)
Medication	13	8	6	40	51	25 (0–478)
Other physicians fee	9	18	107	17	32	24 (0–3,518)
Transport	3	4	18	8	34	14 (0–538)
Further non-drug therapy	0	0	0	209	23	17 (0–8,153)
Rehabilitation	0	0	96	83	0	8 (0–3,638)
Total costs from the GKV perspective (range) [95% CI]	200 (3–1,020) [120–281]	244 (3–950) [164–325]	616 (8–4,245) [304–927]	934 (8–8,314) [428–1,440]	2,164 (5–26,346) [857–3,471]	911 (3–26,346) [395–1,426]

*Data may not add exactly because of rounding.

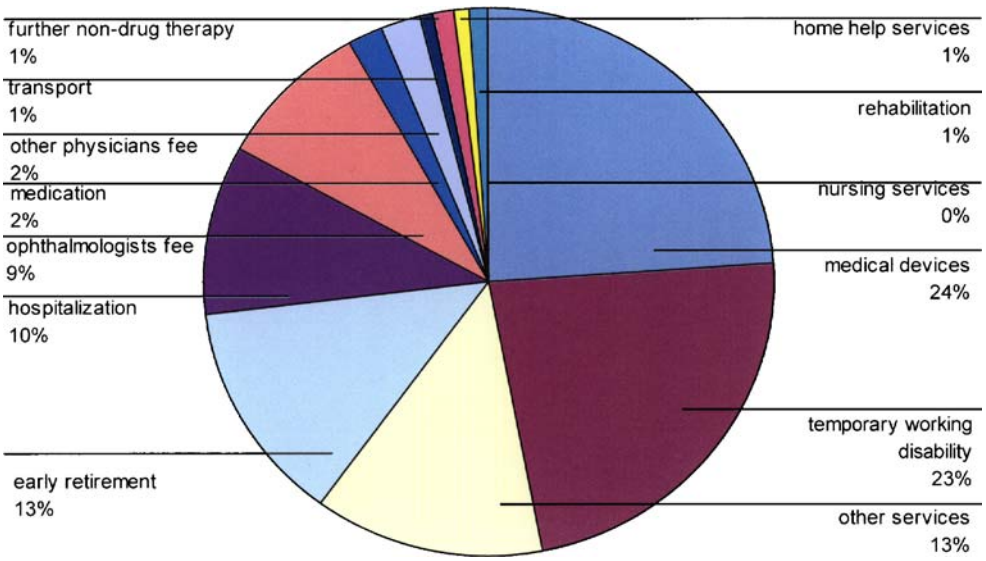

Fig. 1 The proportion of the total costs from the societal perspective (per year and patient, diabetic retinopathy, all stages, Germany, 2002)

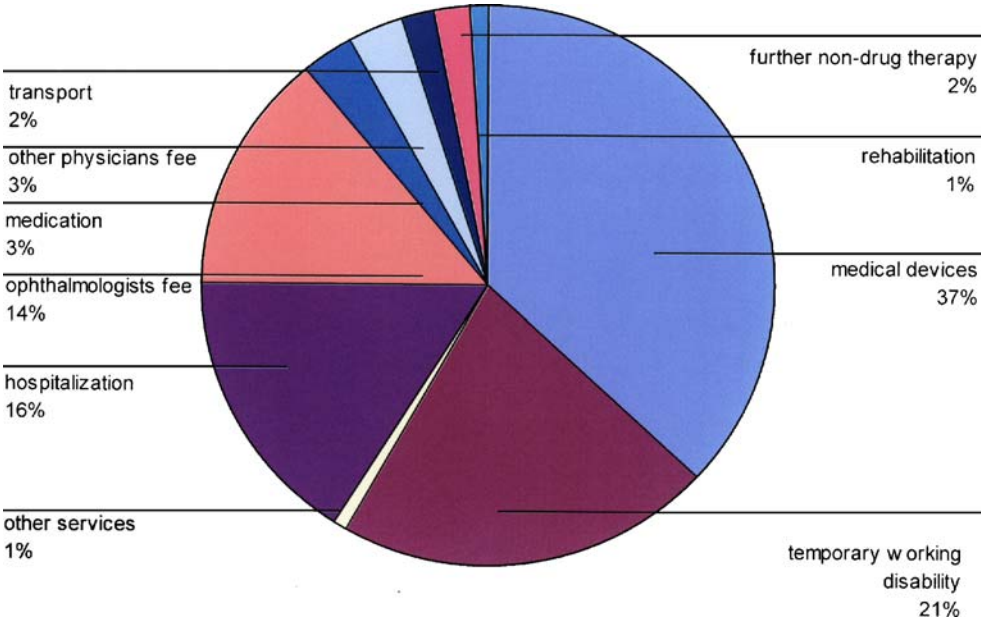

Fig. 2 The proportion of the total costs from the health insurance perspective (per year and patient, diabetic retinopathy, all stages, Germany, 2002)

National-level cost estimation of DR

The total cost related to DR in adult diabetic patients in Germany was calculated based on the cost of DR per patient and its prevalence in Germany. The prevalence of known and unknown diabetes in Germany is between 7–8 million, which is about 8.5% [20]. These estimates date from 2005; other estimates of the total diabetes prevalence range from 3.2% (n=2.64 million) [21] to 15.6% (n=12.85 million) [22]. The following estimates were used for the prevalence of DR in diabetic patients in Germany: 26.6% [23], range 15.4–33.3% [24, 25]. Bertram et al. (1997) estimated the prevalence of maculopathy in diabetic patients at 8.4% [23]. Nationally, there were roughly 2.45 million diabetic patients (range 1.67–2.92 million) with diabetes-related retinopathy during 2002, using the estimates from the literature [23–25]. The average costs of DR in Germany were calculated for year 2002. The prevalence estimates were multiplied by the annual costs per patient (€1,433 from the societal perspective and €911 from the GKV perspective). Annual costs resulting from DR were estimated at €3.51 bn (range €2.39 bn–€4.18 bn) and €2.23 bn (range €1.52 bn–€2.66 bn) from the societal and the GKV perspectives respectively.

Discussion

Diabetic retinopathy generates substantial economic burden in adults with Type 1 or Type 2 diabetes. Medical devices, temporary and permanent working disability, hospitalization and other costs because of tax exemptions or blindness

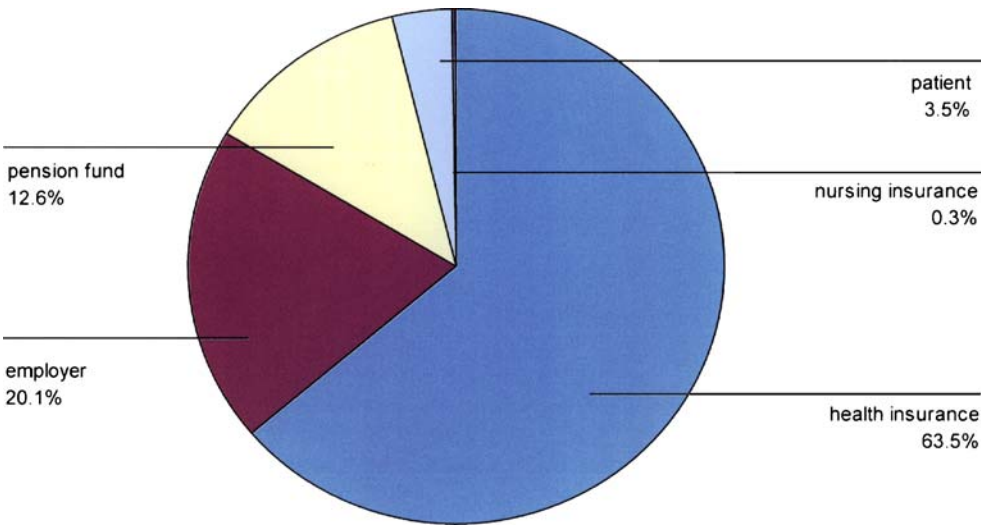

Fig. 3 Percent distribution of costs among payers (all payers, diabetic retinopathy, all stages, Germany, 2002)

allowances are the major components of these costs. Our findings suggest that a patient in the severe retinopathy stage resulting from diabetes costs on average at least 10 times more than a patient with mild NPDR, with costs increasing substantially as retinopathy progresses. These findings are consistent with previous reports that more progressive stages of diabetic complications are more expensive than less progressive ones [26, 27].

In estimating direct and indirect costs of the DR, we identify the costs that would have been avoided if the progression of the DR had not occurred. The total cost of individuals with DR in Germany in 2002 was estimated to be about €3.51 bn more than it would have been without the retinopathy resulting from diabetes. The difference represents about 1.50% (range 1.02–1.78%) of the total health-care expenditure €234.2 bn [28] in that year.

In our study, patients were grouped based on the worst affected eye, which is relevant for estimation of medication costs, ophthalmologists' fees and other costs which result from treatment of retinopathy. On the other hand, transportation costs, temporary disability, early retirement and nursing services depend on general vision, so from the societal perspective it does make sense to group patients based on better eye. We believe, however, that the grouping of patients based on the worst affected eye is justified because of the following reasons: first, during DR both eyes are usually affected, so we expected between-eye correlation for impact of DR to be present; and second, the severity of DR is commonly graded according to the worst affected eye, and classification must be kept consistent throughout the study. Given that the present study was not specifically designed to capture aspects of visual impairment, information on visual acuity loss occurring secondary to retinopathy was limited, but should be considered in future studies. More studies are needed to better assess the economic burden of DR, and to identify the subpopulations among people having DR who currently bear a disproportionately higher economic burden. Further research on impaired visual acuity in subjects with DR which might impose considerable costs on the society, individuals with diabetes and their families, is warranted.

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