



# Health Care Use and Costs in Individuals With Diabetes With and Without Comorbid Depression in Germany: Results of the Cross-sectional DiaDec Study

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## OBJECTIVE

Increased health care use and costs have been reported in individuals with diabetes with comorbid depression. Knowledge regarding cost differences between individuals with diabetes alone and those with diabetes and diagnosed/undiagnosed depression is, however, scarce. We therefore compared use and costs for patients with diabetes and no depression and patients with diabetes and documented depression diagnosis or self-reported depression symptoms for several cost components, including mental health care costs.

## RESEARCH DESIGN AND METHODS

Data from a 2013 cross-sectional survey of randomly sampled members of a nationwide German statutory health insurance (SHI) provider with diabetes ( $n = 1,634$ ) were linked individually with SHI data covering four quarters before and after the survey. Self-reported depression symptoms were assessed with the Patient Health Questionnaire-9, with depression diagnosis taken from SHI data. We analyzed health care use and costs, using regression analysis to calculate cost ratios (CRs) with adjustment for sociodemographic/socioeconomic factors and comorbidities for two groups: 1) those with no symptoms and no diagnosis and 2) those with symptoms or diagnosis. In our explorative subanalysis we analyzed subgroups with either symptoms or diagnosis separately.

## RESULTS

Annual mean total health care costs were higher for patients with comorbid depression (EUR 5,629 [95% CI 4,987–6,407]) than without (EUR 3,252 [2,976–3,675], the CR being 1.25 [1.14–1.36]). Regression analysis showed that excess costs were highly associated with comorbidities. Mental health care costs were very low for patients without depression (psychotherapy EUR 2; antidepressants EUR 4) and still relatively low for those with depression (psychotherapy EUR 111; antidepressants EUR 76).

## CONCLUSIONS

Costs were significantly higher when comorbid depression was present either as symptoms or diagnosed. Excess costs for mental health services were rather low.

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Diabetes is a highly prevalent disease. Approximately 7–8% of the adult German population has a type 2 diabetes diagnosis (1). According to a meta-analysis by Ali et al. (2), the prevalence of depression among individuals with type 2 diabetes is roughly twice as high as in individuals without diabetes. Diabetes with comorbid depression is associated with significant health impacts, i.e., reduced quality of life, increased mortality, and higher health care use and costs (3). Total costs in people with diabetes and depression are described to be 1.4–4.0 times higher than in people with diabetes alone (4–6). A systematic review by Lehnert et al. (6) found that most of these excess costs seem to originate from general health care use due to somatic treatment, and only a small proportion is due to increased mental health care use. Hutter et al. (7) suggest that a more severe somatic disease status is inherent for patients with diabetes and comorbid mental disorders and might explain the higher costs. Moreover, many individuals with diabetes and depression do not receive a suitable depression diagnosis (~45% according to Li et al. [8]).

Evidence suggests that depression often goes unrecognized or at least undiagnosed, thus potentially resulting in a lack of targeted treatment and various specialists being consulted to treat the various somatic symptoms. Health care planning focuses on providing adequate patient care for individuals with diabetes and depression and reducing unnecessarily high costs. Further research into the following questions is needed to support decision makers: How much higher are costs in patients with diabetes and depression, either diagnosed or undiagnosed, than in those with diabetes alone? And what proportion of costs is attributable to somatic care and mental health care?

A number of workgroups have compared costs between patients with diabetes alone and patients with diabetes and depression, whereby depression is defined based on diagnosis (4,5). For filling the research gap regarding higher costs due to comorbid depression, a combination of depression diagnoses and self-reported depression symptoms could be used to capture undiagnosed depression. Furthermore, detailed analyses of mental health costs ought also to allow for further investigation into the origin

of costs relating to somatic and mental health treatment.

Egede et al. (9) went one step further and divided the group of individuals with diabetes and depression more precisely into four subgroups according to the presence of depression diagnoses and depression symptoms: “no depression” (no symptoms, no diagnosis), “unrecognized depression” (symptoms, no diagnosis), “asymptomatic depression” (no symptoms, diagnosis), and “symptomatic depression” (symptoms, diagnosis). However, costs for mental health care were not reported.

This study aims to 1) compare health care use and costs in German individuals with diabetes and comorbid depression considering both depression symptoms and diagnoses, 2) analyze cost categories and the proportion of costs due to mental or somatic health treatment, and 3) analyze whether potential differences within the groups can be explained by age, sex, sociodemographic and socioeconomic variables, diabetes severity, and other comorbidities. Within an explorative subgroup analysis, we further divided the depression group into those with comorbid depression symptoms, those with comorbid depression diagnosis, and those with both, also taking mental health costs into account.

## RESEARCH DESIGN AND METHODS

### Study Design

Between March and December 2013, a cross-sectional postal survey was conducted among a random sample of individuals with diabetes from the German statutory health insurance (SHI) provider pronova BKK and combined with a retrospective and prospective assessment of SHI data. We individually linked baseline questionnaire data to the SHI data covering an observation period of nine quarters for each individual, namely, the survey quarter and the four prospective and retrospective quarters. Details can be found in the study protocol (10).

### Participants and Procedures

In February 2013, the SHI provider identified all insured persons with diabetes using data from the entire year 2011, the most recent year with complete information available. Diabetes was defined as 1) a regular documented diabetes diagnosis (ICD-10 E10–E14) in three of four quarters, 2) at least two prescriptions

of antihyperglycemic drugs (Anatomical Therapeutic Chemical [ATC] code A10) within 2011, or 3) a single A10 prescription combined with a diabetes diagnosis or a single A10 prescription combined with either a blood glucose or HbA<sub>1c</sub> measurement in the same quarter (11). Exclusion criteria were as follows: being age <18 or >80 years, being in the care of a legal guardian, having long-term care level 2 or 3, having intellectual retardation (ICD-10 codes F70–F79), or being in palliative therapy (Z51.5). Of the 46,566 individuals meeting the inclusion criteria, 4,053 were randomly selected and invited to participate in the study. A total of 409 individuals were excluded for the following reasons: having dementia, not having self-reported diabetes, not having valid contact data in Germany, having died, having switched SHI, or having insufficient knowledge of the German language. Of 3,644 eligible persons, 1,860 individuals returned the completed questionnaire with a signed consent form (51.0% responded). Responders do not differ from nonresponders with respect to depression (12). A total of 1,634 participants were included in the analysis after exclusion of 226 participants due either to missing information in the questionnaire ( $n = 166$ ) or to an incomplete insurance period ( $n = 60$ ), or for both reasons ( $n = 3$ ). Further information on the case number calculation and the recruitment procedure is presented in the study protocol (10).

### Definitions

#### Depression

Depression was defined as having a depression diagnosis within the observation period of nine quarters, covering the years 2012–2014, and/or having depression symptoms according to the Patient Health Questionnaire-9 (PHQ-9) from the survey.

Depression diagnosis was defined as having at least one depression diagnosis in SHI data (ICD-10 codes F32.0–F32.9, F33.0–F33.9, F34.1, F38.1, or F41.2). Depression symptoms were defined as a disclosure of major/other depression in the PHQ-9 (13), with two or more of the nine symptoms having been present for at least “more than half the days” in the past 2 weeks and one of the symptoms being depressed mood or anhedonia (13). PHQ-9 was selected because it uses the nine criteria of a depressive disorder

diagnosis according to the DSM-IV (13). Furthermore, it is a well-validated and widely used questionnaire (14), which allows comparison with other studies.

The base case considered the two groups, Group A (diabetes without any depression) and Group B (diabetes with depression). For the purposes of the subgroup analysis, we adapted the method of Egede et al. (9), in which the diagnosis and symptoms of depression were distinguished and individuals categorized into four subgroups, where Group 1 had neither depression symptoms nor a diagnosis of depression (identical to Group A), Group 2 had no depression symptoms but a diagnosis of depression, Group 3 had depression symptoms but no diagnosis of depression, and Group 4 had both depression symptoms and a diagnosis of depression.

#### Health Care Use and Costs

Health care use and costs were derived from the 2012–2014 SHI data and analyzed for three areas, 1) inpatient care, 2) outpatient care, and 3) medication and assistive devices, and then totaled. A detailed description of how health care use and costs were defined is presented in Supplementary Material.

We report total use and costs for each area, with the proportions indicating treatment of depression (e.g., antidepressant drugs) or mental health care in general when a more detailed identification was not possible (e.g., psychotherapy).

Inpatient care covers all full-inpatient, semi-inpatient, and precare treatment. Reimbursed fee schedule positions of the doctors' fee scale ("Einheitlicher Bewertungsmaßstab" [15]) were used for outpatient care. All services provided by pharmacies and reimbursed by the SHI were included as medications and assistive devices. Over-the-counter medications were not considered. Diagnosis-related groups, hospital department codes, doctors' specialist groups, fee schedule positions, and the ATC code were used to extract health care services related to mental health treatment.

Health care costs from the SHI perspective were calculated by use of net costs from SHI data. We calculated average 1-year costs were calculated by dividing the costs of nine quarters by the factor 2.25.

#### Covariates

The following covariates were taken from the questionnaire: marital status, living

with a partner, country of birth (Germany, other), employment status, retirement status, duration of education ( $\leq 10$ ,  $11-13$ ,  $\geq 14$ ) according to the International Standard Classification of Education 1997 (16), and duration and type of diabetes.

Five covariates from the SHI data referring to the time prior to the survey were also considered: 1) age at invitation to participate in the study, 2) sex, 3) diabetes severity according to the adapted Diabetes Complications Severity Index score (17) based on diagnosis data from four quarters prior to the survey, 4) use of antihyperglycemic medication in 2012 (ATC codes A10A and A10B [18]), and 5) the number of comorbidities in 2012. Comorbidities were assessed with the German morbidity-oriented risk compensation scheme. This system covers 80 either "severe" or "costly and chronic" diseases. Each patient's comorbidity profile was determined according to their total number of diagnoses of the 80 included (10,19,20).

#### Statistical Analyses

All variables were described for the full sample and stratified by depression groups. Mean and SD are used for the description of continuous variables, while absolute and relative frequencies are shown for the categorical variables.

#### Health Care Use and Costs

Use and costs are given as 1-year mean per capita with 95% CI with use of bias-corrected and accelerated bootstrap procedures due to the right-skewed distribution (21). For adjustment for possible sociodemographic differences between the depression groups, all variables were age/sex standardized to the German population on 31 December 2013 according to the Federal Statistical Office. The age strata  $< 65$ ,  $\geq 65$  to  $< 70$ ,  $\geq 70$  to  $< 75$ , and  $\geq 75$  years were used. Costs are given in Euro at the 2014 rate, the most recently analyzed year. For this purpose, costs from previous years were inflated to 2014 levels with the German Consumer Price Index (22).

#### Regression Models

Multiple regression models were used to estimate the association between depression groups and the cost categories total health care, inpatient care, outpatient care, and medication and assistive devices. We compared the costs of Group B with the costs of Group A as reference

by estimating a cost ratio (CR) in each model. For the explorative subgroup analysis, the costs of Groups 2–4 were compared with the costs of Group 1 (i.e., Group A). CRs were adjusted stepwise for age and sex (model 1), employment, retirement, duration of education, country of birth, marital status, living with a partner (model 2), and diabetes severity, intake of antihyperglycemic medication, diabetes duration, diabetes type, and number of comorbidities (model 3). The CRs for the fully adjusted model 3 are presented in Table 4; the results of all models with stepwise adjustment are presented in Supplementary Tables 1 and 2. Manual stepwise adjustment of the models was used for investigation of which block of parameters may influence cost relations and to what extent.  $\gamma$ -Regression models were fitted as one-part models for estimation of CRs for total health care costs and costs for outpatient care and medication, where cost values  $> 0$  for nearly all individuals. Given the high proportion of people with zero costs, two-part models were used for estimation of CRs for inpatient care (23,24). We combined both parts of the model using generalized linear models (first Poisson regression model with robust error variance [25,26], second  $\gamma$ -regression model).

We performed all analyses using SAS, version 9.4.

## RESULTS

#### Description of Study Population

Table 1 shows the number of individuals within each depression group and a description of the study population. Within the sample, we had a high proportion of drug treatment and a diabetes duration of  $> 10$  years.

#### Health Care Use and Costs

Table 2 shows the age- and sex-standardized proportions and mean numbers and costs of use from the base case analysis for the total sample and for Groups A and B. Results for the subgroup analysis of Groups 1–4 are presented in Table 3.

Almost one-half of the sample used inpatient services (42.8%), whereas nearly all individuals used outpatient care or medications/assistive devices ( $> 99\%$ ) at least once during the study period. When we looked at mental health care use, a mean of 6.4% of the total sample received psychotherapy and 22.7% took

Table 1—Description of the analyzed study population

Characteristics		Total sample with diabetes (n = 1,634)	Group A/Group 1: no depression symptoms,* no depression diagnosis† (n = 1,184)	Group B: with depression symptoms* and/or with depression diagnosis† (n = 450)	Group 2: no depression symptoms,* with depression diagnosis† (n = 84)	Group 3: with depression symptoms,* no depression diagnosis† (n = 261)	Group 4: with depression symptoms,* with depression diagnosis† (n = 105)
Sex, n (%)‡	Male	1,014 (62.1)	778 (65.7)	236 (52.4)	51 (60.7)	127 (48.7)	58 (55.2)
	Female	620 (37.9)	406 (34.3)	214 (47.6)	33 (39.3)	134 (51.3)	47 (44.8)
Age, mean (SD)‡	Years	67.0 (9.9)	67.7 (9.6)	65.4 (10.4)	69.9 (10.3)	66.6 (9.9)	61.3 (10.9)
	Age classes, n (%)‡						
	<65 years	567 (34.7)	366 (30.9)	201 (44.7)	34 (40.5)	99 (37.9)	68 (64.8)
	65–80 years	1,067 (65.3)	818 (69.1)	249 (55.3)	50 (59.5)	162 (62.1)	37 (35.2)
Marital status, n (%)§	6 missing	6 missing	5 missing	1 missing	0 missing	1 missing	0 missing
	Married	1,222 (75.1)	915 (77.6)	307 (68.4)	58 (69.1)	185 (71.2)	64 (61.0)
	Single, separated, divorced, widowed	406 (24.9)	264 (22.4)	142 (31.6)	26 (31.0)	75 (28.9)	41 (39.1)
Living with a partner, n (%)§	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing
	Yes	1,294 (79.2)	969 (81.8)	325 (72.2)	61 (72.6)	193 (74.0)	71 (67.6)
	No	340 (20.8)	215 (18.2)	125 (27.8)	23 (27.4)	68 (26.1)	34 (32.4)
Country of birth, n (%)§	2 missing	2 missing	0 missing	0 missing	0 missing	0 missing	0 missing
	Germany	1,442 (88.4)	1,059 (89.6)	383 (85.1)	64 (76.2)	234 (89.7)	85 (81.0)
	Other country	190 (11.6)	123 (10.4)	67 (14.9)	20 (23.8)	27 (10.3)	20 (19.1)
Occupation, n (%)§	37 missing	37 missing	28 missing	9 missing	1 missing	5 missing	3 missing
	Yes	412 (25.8)	297 (25.7)	115 (26.1)	25 (30.1)	63 (24.6)	27 (26.5)
	No	1,185 (74.2)	859 (74.3)	326 (73.9)	58 (69.9)	193 (75.4)	75 (73.5)
Retirement, n (%)§	20 missing	20 missing	18 missing	2 missing	0 missing	1 missing	1 missing
	Yes	1,124 (69.6)	839 (72.0)	285 (63.6)	59 (70.2)	173 (66.5)	53 (51.0)
	No	490 (30.4)	327 (28.0)	136 (36.4)	25 (29.8)	87 (33.5)	51 (49.0)
Duration of education, n (%)§	9 missing	9 missing	7 missing	2 missing	0 missing	2 missing	0 missing
	≤10 years	347 (21.4)	221 (18.8)	126 (28.1)	24 (28.6)	71 (27.4)	31 (29.5)
	11–13 years	930 (57.2)	688 (58.5)	242 (54.0)	47 (56.0)	143 (55.2)	52 (49.5)
	≥14 years	348 (21.4)	268 (22.8)	80 (17.9)	13 (15.5)	45 (17.4)	22 (21.0)
Diabetes duration, mean (SD)§	42 missing	42 missing	28 missing	14 missing	3 missing	7 missing	4 missing
	Years	10.8 (8.2)	10.7 (8.1)	11.1 (8.6)	10.9 (7.3)	10.9 (8.8)	11.9 (9.1)
Diabetes type, n (%)§	15 missing	15 missing	9 missing	6 missing	2 missing	3 missing	1 missing
	Type 1	131 (8.1)	97 (8.3)	34 (7.7)	5 (6.1)	16 (6.2)	13 (12.5)
	Type 2	1,393 (86.0)	1,018 (86.6)	375 (84.5)	72 (87.8)	216 (83.7)	87 (83.7)
	Other type	13 (0.8)	8 (0.7)	5 (1.1)	2 (2.4)	3 (1.2)	0 (0.0)
	Unknown	82 (5.1)	52 (4.4)	30 (6.8)	3 (3.7)	23 (8.9)	4 (3.9)
Antihyperglycemic medication, n (%)‡	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing
	None	298 (18.2)	208 (17.6)	90 (20.0)	14 (16.7)	52 (19.9)	24 (22.9)
	Insulin (A10A)	227 (13.9)	164 (13.9)	63 (14.0)	13 (15.5)	35 (13.4)	15 (14.3)
	Others (A10B)	835 (51.1)	625 (52.8)	210 (46.7)	36 (42.9)	133 (51.0)	41 (39.1)
	Both	274 (16.8)	187 (15.8)	87 (19.3)	21 (25.0)	41 (15.7)	25 (23.8)
Diabetes severity, mean (SD)‡	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing
	aDCSI score	3.1 (2.2)	2.9 (2.1)	3.4 (2.3)	3.5 (2.4)	3.6 (2.3)	3.0 (2.2)
Number of comorbidities, mean (SD)‡	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing	0 missing
	Number of HMG¶	3.7 (2.1)	3.3 (1.9)	4.5 (2.4)	3.9 (2.1)	4.8 (2.5)	4.4 (2.3)

Data are absolute proportion (n) and relative proportion (%) or mean (SD) as indicated. aDCSI, adapted Diabetes Complications Severity Index. \*As per PHQ-9 inventory from self-report. †As per ICD-10, German Modification, diagnoses from SHI data. ‡As per SHI data. §As per self-report. ¶Hierarchical morbidity groups (HMG) in 2012.

**Table 2—Age- and sex-standardized mean health care use: proportions, numbers, and costs (with 95% CIs) for the base case analysis**

	Total sample with diabetes ( <i>n</i> = 1,634)	Group A (identical to Group 1): no depression symptoms,* no depression diagnosis† ( <i>n</i> = 1,184)	Group B: with depression symptoms* and/or with depression diagnosis† ( <i>n</i> = 450)
Proportions (%) of individuals using health care services within nine quarters			
Total health care	100.0	100.0	100.0
Inpatient care			
Total	42.8 (39.4–46.2)	35.4 (31.4–39.7)	56.2 (50.3–61.7)
Mental health treatment	1.8 (1.0–3.1)	0.2 (0.0–0.9)	4.6 (2.5–7.7)
Outpatient care			
Total	100.0	100.0	100.0
Mental health treatment	24.1 (21.1–27.3)	11.1 (8.6–14.5)	47.4 (41.7–53.1)
Psychotherapy	6.4 (4.7–8.6)	1.0 (0.3–2.8)	15.8 (11.6–20.5)
Medications and assistive devices			
Total	99.7 (99.1–99.9)	99.5 (98.7–99.8)	100.0
Antidepressants	22.7 (19.8–25.7)	5.3 (3.8–7.6)	53.6 (48.0–59.5)
Mean 1-year number of health care uses per person			
Inpatient care			
Total, hospitalizations per person	0.5 (0.4–0.5)	0.3 (0.3–0.4)	0.7 (0.6–0.8)
Total, length of stay (days) per person	3.6 (3.1–4.2)	2.3 (1.9–2.9)	5.9 (4.8–7.4)
Treatment for mental health: hospitalizations per person	0.0	0.0	0.0
Treatment for mental health: length of stay (days) per person	0.4 (0.2–0.9)	0.0	1.1 (0.5–2.1)
Outpatient care			
Total, treatment cases‡ in total per person	15.3 (14.9–15.8)	13.9 (13.4–14.4)	17.8 (17.0–18.6)
Treatment for mental health: treatment cases‡ within specific specialists' groups per person	0.5 (0.4–0.6)	0.1 (0.1–0.2)	1.1 (0.9–1.4)
Psychotherapy, days per person	0.1 (0.1–0.2)	0.0	0.3 (0.2–0.4)
Medications and assistive devices			
Total, packs per person	32.6 (30.8–34.6)	28.5 (26.9–30.3)	39.6 (36.4–43.8)
Antidepressants, packs per person	0.8 (0.7–1.0)	0.1 (0.1–0.1)	2.0 (1.7–2.5)
Mean 1-year costs (EUR) per person			
Total health care	4,087 (3,776–4,478)	3,252 (2,976–3,675)	5,629 (4,987–6,407)
Inpatient care			
Total	1,523 (1,312–1,816)	1,100 (914–1,403)	2,338 (1,886–2,960)
Mental health treatment	87 (43–172)	1 (0–2)	238 (115–444)
Outpatient care			
Total	1,197 (1,142–1,274)	1,048 (985–1,146)	1,465 (1,373–1,575)
Mental health treatment	67 (51–91)	11 (7–17)	162 (121–216)
Psychotherapy	43 (28–65)	2 (0–11)	111 (71–167)
Medications and assistive devices			
Total	1,366 (1,243–1,544)	1,104 (1,004–1,238)	1,826 (1,569–2,234)
Antidepressants	31 (23–45)	4 (2–11)	76 (56–107)

\*As per PHQ-9 inventory from self-report. †As per ICD-10, German Modification, diagnoses from SHI data. ‡Treatment of one individual within one quarter by one physician.

antidepressants. The mean number of packs of antidepressants in 1 year across all 1,634 participants was 0.8, compared with 32.6 packs of all medications and assistive devices.

The age- and sex-standardized mean 1-year total health care costs for the full sample were EUR 4,087 (95% CI 3,776–4,478). Group A (without depression) had mean costs of EUR 3,252 (2,976–3,675) and Group B (with depression) EUR 5,629 (4,987–6,407). Results for the subgroup analysis ranged from EUR 3,252 (2,976–3,675) for Group 1 to EUR 4,524 (3,650–

5,909) for Group 2, EUR 5,484 (4,618–6,702) for Group 3 and EUR 6,078 (5,057–7,829) for Group 4.

Costs resulting explicitly from mental health care for Group A/Group B were found to be EUR 1/EUR 238 for inpatient care, EUR 11/EUR 162 for outpatient care, and EUR 4/EUR 76 for antidepressant medications. In the subgroup analysis of Groups 1/2/3/4, these costs were found to be EUR 1/0/174/453 for inpatient care, EUR 11/25/132/271 for outpatient care, and EUR 4/30/42/149 for antidepressant medications.

## CRs

Table 4 presents fully adjusted CRs in comparisons of the costs of Group B with those of Group A, along with comparisons of the costs of Groups 2, 3, and 4 with those of Group 1 for the subgroup analysis. The values are >1 and are predominantly significant. This indicates higher costs in Group B compared with Group A and higher costs in Group 2, 3, and 4 compared with Group 1. Results for the CRs with stepwise adjustment are presented in Supplementary Tables 1 and 2 and suggest that diabetes severity and

**Table 3—Age- and sex-standardized mean health care use: proportions, numbers, and costs (with 95% CIs) for the subgroup analysis**

Subcategory descriptions		Group 1 (identical to Group A): no depression symptoms,* no depression diagnosis† (n = 1,184)	Group 2: no depression symptoms,* with depression diagnosis† (n = 84)	Group 3: with depression symptoms,* no depression diagnosis† (n = 261)	Group 4: with depression symptoms,* with depression diagnosis† (n = 105)
% individuals using health care services within 9 quarters					
Total health care		100.0	100.0	100.0	100.0
Inpatient care	Total inpatient care	35.4 (31.4–39.7)	42.4 (29.3–59.1)	54.4 (46.2–62.3)	64.6 (54.6–74.0)
	Inpatient mental health treatment	0.2 (0.0–0.9)	0.0	2.8 (1.0–6.6)	9.6 (4.5–17.8)
Outpatient care	Total outpatient care	100.0	100.0	100.0	100.0
	Outpatient mental health treatment	11.1 (8.6–14.5)	26.2 (15.2–43.2)	42.7 (34.9–50.6)	64.7 (55.1–73.6)
Medications and assistive devices	Psychotherapy	1.0 (0.3–2.8)	1.7 (0.0–5.5)	18.4 (12.3–25.7)	18.9 (11.6–28.3)
	Total medications and assistive devices	99.5 (98.7–99.8)	100.0	100.0	100.0
Inpatient care	Antidepressants	5.3 (3.8–7.6)	37.3 (21.0–52.5)	45.5 (37.6–53.8)	75.8 (66.2–83.4)
	Total inpatient care: mean hospitalizations per person	0.3 (0.3–0.4)	0.5 (0.4–0.8)	0.6 (0.5–0.7)	0.9 (0.7–1.3)
	Total inpatient care: mean length of stay (days) per person	2.3 (1.9–2.9)	3.7 (2.4–5.9)	5.2 (3.9–7.3)	7.6 (5.5–11.3)
	Inpatient treatment for mental health: mean hospitalizations per person	0.0	0.0	0.0	0.1 (0.0–0.2)
	Inpatient treatment for mental health: mean length of stay (days) per person	0.0	0.0	0.7 (0.1–2.3)	2.3 (0.9–4.7)
Outpatient care	Total outpatient care: mean treatment cases‡ in total per person	13.9 (13.4–14.4)	15.7 (14.1–18.1)	17.5 (16.5–18.5)	19.0 (17.5–20.9)
	Outpatient treatment for mental health: mean treatment cases‡ within specific specialists' groups per person	0.1 (0.1–0.2)	0.3 (0.2–0.6)	1.0 (0.7–1.3)	1.8 (1.4–2.3)
Medications and assistive devices	Psychotherapy: mean days per person	0.0	0.0	0.3 (0.2–0.5)	0.5 (0.3–0.7)
	Total medications and assistive devices: mean packs per person	28.5 (26.9–30.3)	40.4 (32.9–51.9)	35.9 (32.0–41.1)	45.4 (39.4–54.7)
	Antidepressants: mean packs per person	0.1 (0.1–0.1)	1.0 (0.5–1.6)	1.5 (1.2–2.1)	3.4 (2.7–4.5)
Mean 1-year cost (EUR) per person					
Total health care		3,252 (2,976–3,675)	4,524 (3,650–5,909)	5,484 (4,618–6,702)	6,078 (5,057–7,829)
Inpatient care	Total inpatient care	1,100 (914–1,403)	1,585 (1,052–2,552)	2,173 (1,606–3,071)	2,721 (1,913–4,443)
	Inpatient mental health treatment	1 (0–2)	0	174 (32–594)	453 (189–899)
Outpatient care	Total outpatient care	1,048 (985–1,146)	1,310 (1,096–1,994)	1,429 (1,317–1,562)	1,576 (1,405–1,778)
	Outpatient mental health treatment	11 (7–17)	25 (12–49)	132 (90–210)	271 (187–395)
Medications and assistive devices	Psychotherapy	2 (0–11)	2 (0–8)	103 (56–194)	177 (97–301)
	Total medications and assistive devices	1,104 (1,004–1,238)	1,629 (1,143–2,671)	1,882 (1,488–2,574)	1,781 (1,462–2,244)
	Antidepressants	4 (2–11)	30 (13–81)	42 (30–64)	149 (101–237)

\*As per PHQ-9 inventory from self-report. †As per ICD-10, German Modification, diagnoses from SHI data. ‡Treatment of one individual within one quarter by one physician.



**Table 4—Two models\* of fully adjusted† multiple CRs (95% CI) of health care costs for nine quarters per person**

	Group B vs. Group A	Group 2 vs. Group 1	Group 3 vs. Group 1	Group 4 vs. Group 1
Total health care‡	1.25 (1.14–1.36)§	1.32 (1.11–1.56)§	1.18 (1.06–1.31)§	1.37 (1.17–1.60)§
Inpatient care	1.34 (1.10–1.63)§	1.37 (0.92–2.06)	1.20 (0.95–1.52)	1.71 (1.22–2.39)§
Outpatient care‡	1.20 (1.12–1.27)§	1.44 (1.27–1.62)§	1.12 (1.03–1.20)§	1.18 (1.06–1.33)§
Medications, assistive devices‡	1.23 (1.11–1.36)§	1.19 (0.97–1.45)	1.25 (1.10–1.41)§	1.22 (1.01–1.47)§

\*First model: adjusted CRs for Group A (identical to Group 1) vs. Group B. Second model: adjusted CRs for Group 2/3/4 vs. Group 1 (reference), which is identical to Group A. †CRs are adjusted for age, sex, occupation, receipt of retirement pension, duration of education, country of birth, marital status, living with a partner, diabetes severity, intake of antihyperglycemic medication, diabetes duration, diabetes type, and comorbidities with  $n = 1,544$  (notwithstanding  $n = 1,542$  for medications). ‡ $\gamma$ -Regression. §Two-sided  $P$  value  $< 0.05$ . ||Two-part models.

comorbidities might explain most of the higher costs.

## CONCLUSIONS

### Main Findings

In our population-based study we used data linkage to combine self-reports with SHI data, allowing us to define different dimensions of depression based on current self-reported depressive symptoms and depression diagnoses in SHI data over an ~2-year period. People with diabetes and with self-reported and/or diagnosed depression seem to have higher excess costs than those without any depression. Excess costs could not be explained entirely by comorbidities. In general, the proportion of costs due to treatment of mental illness was low.

Our results show that the total health care cost in patients with diabetes and depression is 1.73 times higher than in patients with diabetes without depression (EUR 5,629 vs. EUR 3,252). These findings are in line with the ratio of 1.69 from the results of Egede et al. (5), which refer to a U.S. population from 2004 to 2011 (USD 17,585 [95% CI 16,472–18,699]) vs. USD 10,411 [10,005–10,816]) and with the ratio of 1.64 from the results of Huang et al. (4), which refer to 2004 data from a Taiwanese sample (NTD 133,077 vs. NTD 80,955 with  $P < 0.001$ ). The subgroup analysis, which differentiates between depression symptoms and depression diagnosis, found costs caused by the group with depression symptoms and diagnosis to be twice as high as in the group without depression, which is in line with the findings of Egede et al. (9) (USD 20,100 vs. USD 10,000). However, the costs in the remaining two groups are rank reversed in comparison with our results (Egede et al. [9] found USD 15,200 for “only symptoms” and USD 16,100 for “only diagnosis,” while we found EUR 5,500 and EUR 4,500, respectively).

The total costs in our study are lower, which may be explained to some extent by higher health care costs in the U.S. than in Germany. In general, the results from the U.S. study cannot be fully transposed to the German health care system.

Interestingly, the age- and sex-standardized mean total costs of the group with depression symptoms but without diagnosis (Group 3) tend to be higher than in the group without acute depression symptoms but with a diagnosis (Group 2). Higher costs seem mainly to result from longer inpatient care and more treatment cases in outpatient care. Considerable costs were also identified for psychotherapy and antidepressants in this group. As no depression diagnoses were documented in that group, it may be assumed that psychotherapy and antidepressant medication might be indicated through diabetes distress or burden due to comorbidities. This hypothesis is supported by the finding that after adjustment for comorbidities, CRs no longer differed between the groups. Antidepressant drugs might also be prescribed for treatment of somatic complaints such as neuropathy. The group with a depression diagnosis but no self-reported symptoms seems to have had lower costs for antidepressants and nearly none for psychotherapy, which might be explained by depression being in remission, requiring less or even no treatment. Nevertheless, as mentioned above, fully adjusted excess costs (CRs) did not differ in either group, which might be due to the higher mean number of comorbidities in the group with no depression diagnosis but with symptoms.

A comparison of the depression groups with the reference group without depression found just a small part of the excess costs to be caused by depression-related health care treatment, which is in line with the findings of Hutter et al. (7). In their

systematic review, they found that higher costs may result from more somatic treatment, which might be explained by a “more severe somatic disease status” in cases of diabetes and comorbid mental disorders. We can confirm that the groups with depression symptoms/diagnosis show higher mean diabetes severity scores and higher general comorbidity.

### Limitations and Strengths

Several limitations have to be considered. Firstly, depression symptoms may appear and disappear in phases, meaning that the self-reporting of symptoms could vary over time. Moreover, a depression diagnosis is a sensitive issue. It is also conceivable that existing symptoms are not perceived by doctors or that diagnoses are deliberately not documented for reasons of social desirability. Thus, neither self-reports nor diagnoses reflect the truth entirely. Combining the two data sources seems to be an adequate approach to minimizing potential classification error.

Secondly, group sizes in the subgroup analysis were small, especially for the two groups with a diagnosis of depression. This resulted in overlapping CIs for many estimates, which limits the statistical results. In particular, the statistical power of the results of the large models 2 and 3 is low. In summary, descriptions and comparisons should be treated with caution.

Our study has several strengths. Firstly, we were able to analyze a large population-based sample of individuals with diabetes, with a response rate of 51%. Further analyses showed that there was no distinction regarding depression diagnosis in 2012 between responders and nonresponders in the Diabetes and Depression: Economic Aspects (DiaDec) study (12). Secondly, individual linkage of self-reports with the SHI data allowed us to





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