Research: Health Economics

Assessment of excess medical costs for persons with type 2 diabetes according to age groups: an analysis of German health insurance claims data

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Abstract

Aim   This cross-sectional study used a large nationwide claims data set to assess the excess medical costs of people with type 2 diabetes according to age group in 2015.

Methods   Data from 291 709 people with diabetes and 291 709 age- and sex-matched controls were analysed. Total costs (expressed as 2015 euros) of outpatient and inpatient services, medication, rehabilitation, and the provision of aids and appliances were examined. Overall and age-stratified excess costs of people with diabetes were estimated using gamma regression with a log-link.

Results   Overall, the estimated total direct costs of a person with type 2 diabetes are approximately double those of a person without diabetes: €4727 vs. €2196, respectively. Absolute excess costs were approximately the same in all age groups (around €2500), however, relative excess costs of persons with diabetes were much higher in younger (~ 334% for < 50 years) than in older age groups (~ 156% for ≥ 80 years). Regional costs, both absolute and excess, partly differed from the national level.

Conclusions   This study complements and updates previous studies on the excess medical costs of people with diabetes in Germany. The results indicate the importance of preventing the development of type 2 diabetes, especially in younger age groups. Longitudinal and regional studies examining changes in prevalence and the development of excess costs in groups with different types of diabetes, and according to age, would be of interest to validate our findings and better understand the avoidable burden of having diabetes.

Diabet. Med. 00, 1–7 (2019)

Introduction

In Germany, the current prevalence of all types of diabetes is estimated to be between 7.2% and 9.9% [1], and is mostly driven by persons diagnosed with type 2 diabetes. A shift in risk factors and demographics is contributing to the increasing prevalence of diabetes worldwide, especially among younger age groups [2,3], and places a high burden on the health and social care systems. According to latest estimates, the global economic burden of diabetes and its complications is estimated at US $1.3 trillion in 2015, and is predicted to increase to US $2.2 trillion in 2030 [4]. Facing this economic

pressure, various programmes have been launched to reduce or delay the risk of type 2 diabetes, including the US Diabetes Prevention Program and the Finnish Diabetes Prevention Study. These programmes have shown that intensive lifestyle interventions could reduce the incidence of type 2 diabetes by > 50% over 3 years, but they were associated with significant costs and resources [5,6].

Cost of illness studies can provide actual costs according to various subgroups, and thus highlight potential prevention priorities or identify subgroups that require more attention in disease management programmes [7,8]. Additional valuable information can be indicated by excess costs, which compare costs of persons with type 2 diabetes with those of people without diabetes. In Germany, routinely collected statutory health insurance data are among the most suitable sources of information due to their large sample size, extensive population coverage (~ 85% during the study period), and

What's new?

- Overall and complication-related excess medical costs of people with type 2 diabetes have been examined previously. However, relative excess medical costs according to age group have not been determined.

- We found that relative excess costs of people with diabetes were much higher in younger (~ 334% for < 50 years) than older age groups (~ 156% for ≥ 80 years), but absolute cost differences were similarly high across all age groups.

- Thus, prevention and efforts to reverse diabetes in affected persons, especially those in younger age groups who have a longer prospect of generating healthcare costs could be valuable.

detailed cost data over several years. There is considerable literature available on the excess costs of diabetes in Germany, particularly the Costs of Diabetes Mellitus (CoDiM) study for the years 2000 to 2010 [9–11]. The CoDiM study has a repeated cross-sectional design and is based on a population of ~ 30 000 persons with type 2 diabetes and age- and sex-matched people without diabetes, insured by Allgemeine Ortskrankenkasse (AOK) in the state of Hesse in central Germany. Important limitations of this study include the relatively small, and probably not representative sample [12], lack of discriminative ability between those with type 1 and type 2 diabetes, a potential lack of representativeness in the total population, and a lack of recent data.

The primary aim of this case–control study is, therefore, to use a large nationwide claims data set to assess total direct excess costs attributable to type 2 diabetes. We also examined the role of age in the analysis of excess costs to derive additional input for health policymaking and prevention. To assess possible differences between national and state-wide estimates, we also examined disease burden at the state level, using the state of Bavaria, in southern Germany, as an example. Bavaria was chosen because it is the second largest state in Germany in terms of population [13] as well as persons admitted to hospital with a diagnosis of diabetes [14]. The state level plays a key role in implementing disease prevention policy in Germany, and disease impact at this level should also be considered (German Social Code SGB V, §20 'Framework agreement of the states to implement the national prevention strategy' https://www.sozialgesetzbuch-sgb.de/sgbv/20.html).

Methods

Data source

This retrospective case–control study is based on data from the largest statutory health insurance provider in Germany,

the Techniker Krankenkasse, which included around 9.1 million insured people in 2015. The data are owned by Techniker Krankenkasse, who approved the intended use and had a contract with KK regarding data protection. All analyses were retrospective and were evaluated on-site at Techniker health insurance. All data were anonymous as required by the strict data protection regulations. Thus, according to official guidelines, consultation with an ethics committee is not required [15].

Identification of persons with diabetes and controls

A cohort of people with type 2 diabetes was identified in the statutory health insurance data in 2012 and their longitudinal data analysed in two studies that focused on the development of diabetic complications and associated costs [16,17]. People with type 2 diabetes were identified based on two outpatient diagnoses in two different quarters and/or one inpatient diagnosis [International Statistical Classification of Diseases and Related Health Problems (ICD)-10 codes E11 and E14]. To differentiate between people with type 1 and type 2 diabetes in uncertain or unspecified cases, additional criteria were considered including the prescription of oral anti-diabetes medications and participation in a disease management programme for people with type 2 diabetes (full details on the database and the selection algorithm have been published recently) [16]. Exclusion criteria included age < 18 years, certain diseases including gestational diabetes (ICD-10 code O24), pancreoprivic diabetes (E13) and pancreatic cancer (E25), and participation in a disease management programme for type 1 diabetes. The follow-up period covered 3 years from 2013 to 2015, but only the most current year, 2015, was used to estimate excess costs.

In this study, we compared diabetes cases with controls. Each person with type 2 diabetes was matched according to age group (age groups with 3-year intervals) and sex with a control person, selected randomly from the same database in 2012. These controls did not have an ICD-10 diagnosis of diabetes (E10–E14) in 2015 and did not participate in a disease management programme for type 1 or type 2 diabetes. Furthermore, they were insured continuously throughout 2015. Prevalence calculations were standardized to the German national population for 2015. To understand the impact of regional vs. national focus, we compared the national results with those for one example regional population.

Statistical analysis

Excess costs of persons with type 2 diabetes were assessed using a gamma regression with a log-link, adjusted for five age groups (< 50, 50–59, 60–69, 70–79 and ≥ 80 years) and sex. We additionally introduced an interaction term between age group and diabetes status to obtain age-stratified excess

cost estimates. In a secondary analysis, we also examined total costs according to region (Bavaria) compared with the rest of Germany. Total costs were expressed from the perspective of statutory health insurance as 2015 euros (€) and include costs of outpatient and inpatient services, medication, rehabilitation, and the provision of aids and appliances. Zero costs were replaced by €1, because the gamma distribution does not include the value zero. This corresponds to other studies and only represents a small proportion (< 5%) of costs [18,19]. Analyses were undertaken in SAS 9.3.

Results

Characteristics of the cohort

Table 1 describes the baseline sociodemographic and clinical characteristics of the study sample in 2012, which consisted of 291 709 people with type 2 diabetes and the same number of people without diabetes; mean age was 65 years and 63% were men. The cohort of people with type 2 diabetes frequently received oral anti-diabetes medication (48%), participated in a disease management programme for type 2 diabetes (62%), and exhibited an adapted Diabetes Complications Severity Index (aDCSI) score of ~ 1.6 (of a maximum of 13) [20].

Table 1 Baseline characteristics (in 2012)

	Type 2 diabetes (N = 291 709)	No diabetes (controls) (N = 291 709)
Men	183 946 (63.1)	183 946 (63.1)
Mean age, years (SD), range	65.1 (11), 18–100	65.0 (11), 18–100
Age groups, years		
< 50	26 834 (9.2)	27 405 (9.4)
50–59	59 941 (20.5)	59 370 (20.4)
60–69	89 503 (30.7)	90 568 (31.0)
70–79	93 133 (31.9)	92 081 (31.6)
≥ 80	22 298 (7.6)	22 285 (7.6)
Participation in the disease management programme for type 2 diabetes	180 188 (61.8)	n.a.
Antidiabetic treatment		n.a.
Oral only	140 279 (48.1)	
Oral + insulin	26 272 (9.0)	
Insulin only	13 984 (4.8)	
No antidiabetic treatment	111 174 (38.1)	
Mean aDCSI* score (SD), range	1.63 (1.76), 0–12	n.a.

Values are given as *n* (%) unless indicated otherwise.
aDCSI, adapted Diabetes Complications Severity Index; n.a., not applicable.
*Seven complications, which in each case can be rated with 0–2 points (except for neuropathy), thus the total score ranges from 0 to 13.

Diabetes prevalence and excess cost analysis

The standardized prevalence of persons with type 2 diabetes in the base year 2015 was 6.0% for men and 4.8% for women (at both the national and regional levels). Table 2 summarizes the results of the gamma regression, where the exponentiated estimates of effects can be interpreted as multiplicative factors. Overall, combining all ages, the results show that the estimated total direct costs of a person with type 2 diabetes are 215% higher than those of a person without diabetes: €4727 [95% confidence limits (CI) 4702, 4752) vs. €2196 (95% CI 2184, 2207) (~ 53.6% diabetes attributable costs). In addition, Fig. 1 illustrates the total costs per person with diabetes and the proportion of excess costs by age group. The figure also illustrates the ratio of excess costs to baseline costs, showing that they are ~ 334% higher than baseline costs in the age group < 50 years and decrease to ~ 156% of baseline costs in the age group ≥ 80 years. Cost values are shown in Table S1. The regional comparison (Fig. S1) showed that the shares of diabetes-attributable costs were similar for Bavaria and the rest of Germany, except for the age groups 70–79 years and ≥ 80 years. In these age groups, the healthcare costs of persons with type 2 diabetes in Bavaria were significantly higher than in the rest of Germany.

Discussion

This study shows not only the latest estimates of the excess costs of type 2 diabetes and the role of different age groups in Germany in 2015, but also the importance of examining both relative and absolute excess costs. To our knowledge, it is the first study to use a large nationwide health insurance database with individual data to examine the excess costs specific to persons diagnosed with type 2 diabetes according to age group. The results show that on average, persons with type 2 diabetes have healthcare costs that are double those of persons without diabetes. However, examined by age group, the healthcare costs of younger people with type 2 diabetes are up to three times higher than those of people without diabetes in the same age group, although the absolute difference in costs is similarly high in all age groups. This indicates both the overall potential of prevention and that the impact of prevention is likely even higher in lower age groups with a shorter duration of diabetes but a longer prospect of generating healthcare costs. These results were shown at a national level and for an example region. For Bavaria, absolute total costs and the share of excess costs of diabetes exceeded that of the national level in older age groups. This indicates an increased potential benefit of effective primary and secondary prevention programmes, but also the importance of determining regional cost distributions.

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Table 2 Analysis of diabetes excess costs in a gamma log-link regression model

Variable	Estimate	(95% confidence limits)	Exp (estimate)*
Intercept	8.023	(8.012; 8.033)	€3049
Male (reference: female)	0.055	(0.047; 0.063)	1.06
Age group (reference: 70–79 years)			
< 50	−1.129	(−1.149; −1.109)	0.32
50–59	−0.757	(−0.772; −0.742)	0.47
60–69	−0.389	(−0.403; −0.376)	0.68
≥ 80	0.236	(0.214; 0.257)	1.27
Type 2 diabetes (reference: no)	0.588	(0.575; 0.602)	1.80
Interaction of age group and diabetes			
Type 2 diabetes, < 50 years	0.618	(0.590; 0.647)	1.86
Type 2 diabetes, 50–59 years	0.377	(0.355; 0.398)	1.46
Type 2 diabetes, 60–69 years	0.172	(0.153; 0.191)	1.19
Type 2 diabetes, ≥ 80 years	−0.142	(−0.172; −0.112)	0.87

exp, exponential function; ref, reference category.
*$P < 0.001$ (all variables significant at this level).

Comparison and cross-verification with other studies

Our study results on diabetes costs are within the range of previously published German studies that use health insurance data and report total direct costs between €4377 (scientific institute of AOK) [21], €5146 (aggregated health insurance data) [22] and €5993 (AOK Hesse) [9] per person with diabetes in 2010. In comparison with these retrospective claims analyses, a population-based survey study by Ulrich *et al.* [18] estimates lower total direct costs of €3352 for 2011 [18]. The average proportion of excess costs appears to be comparable, but was slightly lower in the CoDiM studies and in the study of Ulrich *et al.* (~ 43–45% excess costs or 1.7- to 1.8-fold higher costs for diabetes patients) [9,18], and lower than in the study of Müller *et al.* (threefold higher costs) [21]. Potential reasons for this could be risk selection effects between health insurance funds [23],

time trends and other differences in the cohort characteristics. For example, the CoDiM study showed an increasing share of excess costs from 2000 to 2009 [10], and that excess costs were generally higher for diabetes patients with microvascular complications, and lower for macrovascular complications [11]. This may reflect the fact that macrovascular events can also occur in the control group, without the associated diagnosis of diabetes. The effect of risk selection cannot be underestimated since social health insurance companies with a higher prevalence of persons with type 2 diabetes also have a higher probability of having those persons with type 2 diabetes with higher costs [23]. When comparing average costs of persons with type 2 diabetes or persons with other healthcare utilization calculated using national health insurance data, one must remember that this only accounts for ~ 58% of total healthcare costs [24]. Thus, our overall costs are much lower than other sources [4],
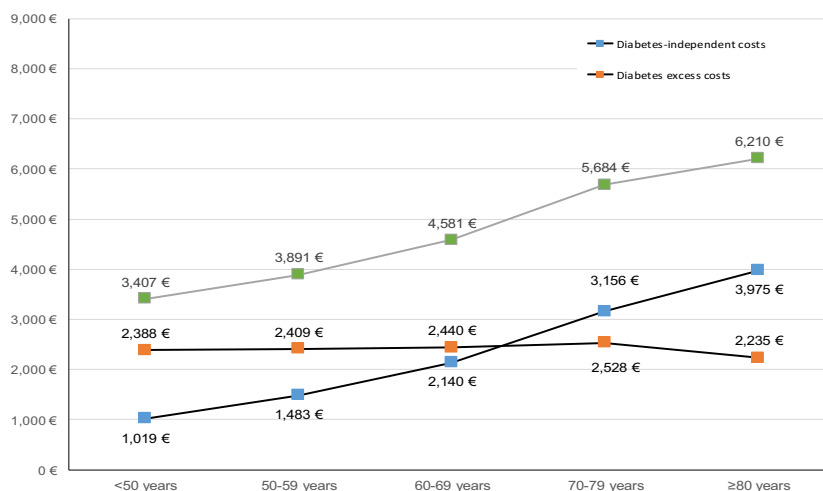

FIGURE 1 Mean annual total direct costs per person showing estimated mean costs of persons with type 2 diabetes, diabetes excess costs and diabetes-independent costs according to age group. Adjusted for five age groups, sex, diabetes status and the interaction between age group and diabetes status. Confidence intervals were very small and are omitted for clarity.

including the costs US $9600 attributed to persons with diabetes by the American Diabetes Association (ADA) [25]. However, our ratio of excess costs of 2.15 is similar to the ADA ratio calculations of 2.3, although ADA calculations and Bommer *et al*. [4] did not differentiate between persons with type 1 and type 2 diabetes. Regarding the role of age, two US studies from the Centers of Disease Control and Prevention indicate a similar direction. One study from 2014 found that a younger age at diagnosis was associated with higher levels of lifetime excess costs of diabetes [26]. A recent study by Shrestha *et al*. [27] showed that compared with people who do not develop diabetes, the healthcare costs of people who develop diabetes are already much higher before the onset of diabetes. Preventing diabetes without all the underlying risk factors of the disease might therefore save less healthcare costs than the excess cost estimate suggests. Similarly, because our study is cross sectional, the excess cost estimates represent only costs associated with prevalent disease and it cannot be concluded that preventing diabetes would lead to annual healthcare savings of the magnitude of our absolute annual excess cost estimates. However, our findings do indicate that preventing a case of diabetes in the young age groups would have approximately the same cost saving potential as preventing a case of diabetes at an older age. Thus, early primary prevention might be a preferred policy strategy, considering that younger persons with type 2 diabetes have a longer prospect of generating healthcare costs. Two recent studies have shown that dietary interventions can reverse diabetes or reduce its severity [28,29] and thus could be considered as an option, in light of the high proportion of excess costs in younger age groups. However, individual-level interventions will likely not have the broad effects of population-level interventions such as taxes on sugar-sweetened beverages or promotion of active commuting [30].

Strengths and weaknesses of this study

Among the key strengths of this study are its large sample size and the nationwide scope of the health insurance database. Furthermore, this study attempted to differentiate persons with type 2 diabetes from other diabetes types, providing updated information regarding the economic impact of type 2 diabetes. Although real-world claims data can be regarded as the best available data source for healthcare costs in Germany, the associated limitations, which must be considered, include a lack of clinical data, unknown duration of diabetes, limited time frame (according to social laws) and reliance on diagnostic accuracy. However, we investigated only total direct medical costs in our research question because indirect costs are not directly captured within claims data and do not affect the majority of individuals over 60 years. Another limitation of this study is that the population was determined in 2012 and does not include incident diabetes cases between 2013 and 2014 or

persons with type 2 diabetes who died between 2012 and 2015. This should not greatly influence the interpretation of our main findings although incident diabetes cases may be associated with lower costs and thereby reduce overall diabetes excess costs, whereas persons with type 2 diabetes who have died, may have higher costs. Thus, our costs reflect the differences between 'stable' persons with type 2 diabetes and 'stable' controls. In addition, remaining selection effects can never be excluded, such as analysing only data from one health insurance company. However, other studies that are based on smaller population samples (instead of the whole population) are affected to the same or an even greater extent.

Finally, regional differences were analysed on an exemplary basis for just one state, Bavaria. This is the second largest state in Germany in terms of population and diabetes cases admitted to hospital [13,14]. Healthcare costs of Bavarians with diabetes in the age groups 70–80 years and > 80 years were higher than those in the rest of Germany. This indicates that the economic benefits of preventive action may vary by region in terms of not only primary, but also secondary prevention. Further research should also clarify the reasons for variations in regional cost burdens, such as differences in disease severity (complications or co-morbidities) or overtreatment, and their association with outcomes.

Conclusions and future perspectives

Given the high share of excess costs due to type 2 diabetes, this study underlines the remarkable economic impact of this disease in Germany and very likely in other countries. Our results indicate that the potential of cost savings remains quite stable in absolute terms but decreases with age in relative terms. Considering that younger persons with type 2 diabetes have a longer prospect of generating healthcare costs, this highlights the benefits of primary prevention in younger age groups. Given the differences of excess costs for diabetes observed at the state level, detailed regional evidence is required to effectively prevent or decrease the economic impact of diabetes. Longitudinal studies investigating the effects of age-at-diagnosis and diabetes duration on the trajectory of excess costs of different diabetes types would be of future interest to validate our findings and facilitate a deeper understanding of the avoidable burden of diabetes.

Funding sources

Competing interests

None declared.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Mean annual total direct costs per person showing diabetes excess costs and diabetes-independent costs according to age groups and comparing Bavaria and the rest of Germany.

Table S1. Comparison of estimated costs of persons with type 2 diabetes with persons without diabetes according to age group.

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