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Original Article: Complications

Reduced incidence of blindness in relation to diabetes mellitus in southern Germany?

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Abstract

Aims We estimated the incidence of blindness in the diabetic and non-diabetic population in 2008 and compared it with results from 1990–1998 in a neighbouring region.

Methods All newly registered blindness allowance recipients in 2008 were drawn up in a German region (population 4.5 million). We estimated sex-specific, age-specific and standardized incidence rates of blindness in the diabetic and the non-diabetic population and relative and attributable risks as a result of diabetes. A comparison to the data from 1990–1998 was performed using log-linear Poisson regression.

Results Four-hundred and sixty-eight cases were drawn up (63% female). One-hundred and twenty-two (26.1%) had diabetes. Blindness incidence rates (per 100 000 person-years) standardized to the 2008 German population were: men 9.1 (95% confidence interval 7.8–10.5), women 9.9 (8.8–11.1); diabetic population: men 21.8 (11.6–31.9), women 19.7 (9.2–30.1); non-diabetic population: men 8.0 (6.6–9.5), women 9.1 (7.9–10.3). Relative risk of blindness, diabetic vs. non-diabetic population: men 2.7 (1.6–4.5), women 2.2 (1.3–3.8). Attributable risk among exposed: 63% in men, 54% in women. Population attributable risk: 12% in men, 8% in women. Incidences of blindness were significantly lower than in all years of the period 1990–1998 in both the diabetic and the non-diabetic population.

Conclusions We found the incidence of blindness to be approximately 2.5-fold higher in the diabetic compared with the non-diabetic population. Fifty-eight per cent of the risk to become blind in diabetic individuals and 9% of the risk to become blind in the entire population were attributable to diabetes. The decrease of the blindness incidence observed during the 1990s may have continued.

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Keywords blindness, diabetes, incidence rate, population-based studies, relative risk

Introduction

In St Vincent (Italy) in 1989 a declaration to improve diabetes care and thus to prevent severe damage in patients with diabetes mellitus was adopted in all European countries [1]. Diabetes has been shown to be the leading cause of blindness in Western countries in the working-age population. Thus, the reduction of diabetes-related blindness has been declared a primary objective in several recommendations, as in the St Vincent Declaration for Europe by the World Health Organization and the International Diabetes Federation [1]. To quantify any improvements, with the beginning of the 1990s the collection of data regarding diabetes-related blindness started. However, even including international studies, corresponding data are scarce.

Incidences of blindness based on blindness allowance data are available for Germany in the 1990s from two districts in Germany (parts of Baden-Württemberg and North-Rhine Westfalia). The incidence of blindness has been found to be approximately 13 per 100 000 person-years in the whole population and approximately 60 in the diabetic population [2]. The age-adjusted risk for blindness was approximately fivefold higher in diabetic individuals compared with non-diabetic individuals [2]. Between 1990 and 1998, a slight reduction (3% per year) of the relative risk for blindness in the diabetic population could be shown [3].

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Several efforts have been undertaken to improve diabetes care in Germany, such as implementing screening initiatives for late complications, including diabetic retinopathy, early interventions, including laser treatment, and structural changes such as the introduction of disease management programmes for diabetes.

The aim of our present study was to estimate the incidence of blindness in the diabetic population and to quantify the risk of blindness attributable to diabetes in Germany in 2008. We used the same approach as in earlier studies and collected data on all blindness allowance recipients in the year 2008 in a part of Baden-Württemberg. All persons in Germany who meet the German criteria for blindness are entitled to blindness allowance, regardless to their income. Using this approach, we therefore can expect an almost complete collection rate of newly blind subjects. We compared our results to the earlier studies to look for changes in the incidence of blindness in the diabetic as well as the non-diabetic populations.

The study is part of a recent evaluation of the diabetes-related co-morbidities according to the goals of the St Vincent Declaration [4,5].

Patients and methods

Study population and data assessment

Since 2005 the welfare authorities of municipalities are responsible for the blindness allowance procedure (35 rural districts and 10 urban districts in the whole federal state of Baden-Württemberg, Southern Germany). In 22 of these 45 districts, directly neighbouring the study region of the former analyses of Trautner *et al.* [2,3], the application and acceptance procedure requires written ophthalmological and medical statements. In the medical statement, relevant diseases are documented, including diabetes mellitus. In the ophthalmological statement, the degree of visual impairment and the most likely underlying cause of blindness is documented. The German criteria for blindness are: visual acuity of 1/50 or less based on the best corrected acuity in the better eye, visual field reduced to a radius of 5° or less, or equivalent reduction of vision, making the person unable to find his or her way.

We assessed all newly registered recipients of the blindness allowance within the study region, between 1 January 2008 and 31 December 2008. Population data were obtained by the Baden-Württemberg State Office for Statistics. The total population in the study region as of June 2008 was 4 915 431 million, approximately half of the whole population of Baden-Württemberg. The diabetic population was estimated by applying age- and sex-specific diabetes prevalences from the former East German diabetes register [6], as these are the only reliable stratum-specific diabetes prevalence data covering all age groups available for the German population and diabetes prevalence has been considered to remain stable during the past decades [7,8].

Statistical analysis

The population with diabetes in each stratum, defined by age (0–59, 60–79 and ≥ 80 years of age) and sex, was estimated by multiplying the population of the study area by the age- and sex-specific prevalence of diabetes, as described above.

Stratum-specific and directly age- and sex-standardized incidence rates of blindness (age strata 0–59, 60–79, ≥ 80 years, standard population 2008 German population) were estimated for the total population, the estimated diabetic population and the non-diabetic population, respectively. The following specific incidence rates were considered: all new cases of blindness in the total population; blindness in individuals with diabetes in the total population; blindness in individuals with diabetes in the estimated diabetic population; and blindness in individuals without diabetes in the non-diabetic population. Additionally, we estimated incidences in the diabetic population standardized to the estimated German diabetic population 2008, yielding a realistic estimation of the incidence in a diabetic population. Relative risks as incidence rate ratios (diabetic vs. Non-diabetic population) were estimated from the standardized (German population) incidence rates, as well as attributable risks among exposed and the population attributable risk because of diabetes, together with 95% confidence intervals [9].

To evaluate our results with the results from Trautner *et al.* [2,3], we compared the 2008 incidences with the incidences in each year between 1990 and 1998 in the diabetic and the non-diabetic population, using Poisson regression in which the linear predictor of the logarithmized blindness incidence depends on age, sex and calendar year. To compare relative risks, we standardized the former data (separately for each year between 1990 and 1998) to the 2008 population.

All analyses were performed using the SAS for Windows 2000, release 9.1 (SAS Institute Inc., Cary, NC, USA).

Results

Study population

During the year 2008, 468 new blindness allowance recipients were registered in the study area. Two hundred and ninety-five (63.0%) were female. The age distribution (0–59, 60–79, ≥ 80 years) was 6.6, 40.6 and 52.8%, respectively. One hundred and twenty-two (26.1%) had diabetes. In 158 subjects from 10 of the 22 counties and cities, we could assess complete lists of causes of blindness. The main causes of blindness (1% unknown) were macular degeneration (44%), followed by diabetic retinopathy (12%), opticus atrophy (10%), glaucoma (4%) and other reasons (29%).

Incidences of blindness

The blindness incidence rates (per 100 000 person-years), standardized to the 2008 German population were: overall 9.7 (95% confidence interval 8.8–10.6), men 9.1 (7.8–10.5), women

9.9 (8.8–11.1); diabetic population 20.7 (95% confidence interval 13.4–27.9), 21.8 (11.6–31.9) in men and 19.7 (9.2–30.1) in women; non-diabetic population overall 8.7 (7.8–9.7), 8.0 (6.6–9.5) in men and 9.1 (7.9–10.3) in women. The relative risk of blindness in the diabetic vs. the non-diabetic population was 2.4 (1.6–3.4) overall, 2.7 (1.6–4.5) in men and 2.2 (1.3–3.8) in women. Attributable risk among exposed was 0.58 (0.63 in men and 0.54 in women) and population attributable risk 0.09 (0.12 in men and 0.08 in women). The stratum-specific incidences and relative and attributable risks are presented in Tables 1 and 2.

Comparison with the former data

Standardized to the 2008 German population, the incidences between 1990 and 1998 were between 58 (44–71) (1991) and 33 (23–43) (1998) in the diabetic population, and between 14 (13–16) (1991) and 12 (11–13) in the non-diabetic population. Applying the intersection-union test [10], the incidences of blindness in 2008 were significantly lower than the incidence in each year of the period 1990–1998, in both the diabetic and the non-diabetic populations (all $P < 0.02$). The relative risks, standardized to the 2008 German population, were between 4.6 (3.6–6.0) (1993) and 2.7 (2.0–3.7) (1998). In all years except 1993, the relative risk did not differ significantly from the 2008 value (confidence intervals overlapping).

Discussion

Study findings and implications

In this population-based study, we estimated incidences and relative risks of blindness in the diabetic and the non-diabetic population, as well as attributable risks in a large region in Southern Germany in 2008, and compared our data with results from the 1990s. We found the incidence of blindness to be 2.4-fold higher in the diabetic compared with the non-diabetic population. Fifty-eight per cent of the risk to become blind in diabetic individuals and 9% of the risk to become blind in the entire population were attributable to diabetes. The incidences were significantly lower compared with a similar earlier study in a directly neighbouring region [2,3] in both the diabetic and the non-diabetic populations. The reduction tends to be more pronounced in the diabetic population, where already during the period between 1990 and 1998 a significant reduction has been found [3].

Unfortunately, we were not able to compare exactly the same regions, but only directly neighbouring districts. In our study, we used the same approach as a study in Württemberg-Hohenzollern in the 1990s [2,3]. During the 1990s, all counties and cities of Württemberg-Hohenzollern assessed medical statements. Data from other districts of Baden-Württemberg were not available for this period. In fact, we have data for the whole federal state of Baden-Württemberg. However, it is up to the district authorities to decide whether the application and

Table 1 Incidences of blindness in men, Southern Germany, 2008

Age (years)	Incidence rates (95% CI) per 100 000 population				Relative and attributable risks (95% CI)		
	IRt	IRp	IRd	IRn	RR	ARE	PAR
Men							
0–59	0.9 (0.5–1.4)	0.2 (0.0–0.4)	11 (2.3–26.5)	0.8 (0.4–1.2)	14.6 (4.2–50.9)	0.93 (0.762–0.98)	0.16 (0–0.329)
60–79	19.6 (15.7–23.9)	6.0 (4.0–8.5)	38.5 (24.4–54.4)	16.1 (12.3–20.3)	2.4 (1.5–3.8)	0.58 (0.344–0.735)	0.18 (0.056–0.285)
≥ 80	93.5 (72.6–117.0)	22.0 (12.6–34)	118.8 (67.9–183.7)	87.8 (65.5–113.2)	1.4 (0.8–2.4)	0.26 (0–0.578)	0.06 (0–0.177)
All	7.2 (6.1–8.3)	1.9 (1.4–2.5)	64.9 (47.5–84.9)	5.4 (4.5–6.4)			
Standard: German population 2008	9.1 (7.8–10.5)	2.4 (1.7–3.1)	21.8 (11.6–31.9)	8.0 (6.6–9.5)	2.7 (1.6–4.5)	0.63 (0.392–0.776)	0.12 (0.037–0.197)
Standard: German diabetic population (estimated)			48.9 (34.3–63.4)				

IRt, blindness incidence in total population; IRd, blindness incidence in population with diabetes; IRp, incidence of blindness in individuals with diabetes in total population; IRn, blindness in individuals without diabetes in population without diabetes; RR relative risk (IRd/IRn); ARE, individual attributable risk of diabetes among exposed; PAR, population attributable risk of diabetes.

Table 2 Incidences of blindness in women, Southern Germany, 2008

Age (years)	Incidence rates (95% CI) per 100 000 population				Relative and attributable risks (95% CI)		
	IRt	IRp	IRd	IRn	RR	ARE	PAR
Women							
0–59	0.8 (0.4–1.2)	0.1 (0.0–0.3)	9.7 (1.2–27)	0.7 (0.3–1.1)	14.8 (3.3–66.1)	0.93 (0.698–0.985)	0.13 (0–0.30)
60–79	20.1 (16.4–24.2)	6.1 (4.2–8.5)	33.8 (23–46.7)	17.1 (13.4–21.3)	2 (1.3–3.0)	0.49 (0.227–0.667)	0.15 (0.33–0.252)
≥ 80	108.2 (92.9–124.7)	26.3 (19.2–34.7)	114.9 (83.1–151.7)	106.3 (89.0–125.0)	1.1 (0.8–1.5)	0.08 (0–0.344)	0.02 (0–0.097)
All	11.6 (10.3–13)	3 (2.4–3.7)	67.4 (53.1–83.3)	9 (7.9–10.2)			
Standard: German population 2008	9.9 (8.8–11.1)	2.6 (2.0–3.2)	19.7 (9.2–30.1)	9.1 (7.9–10.3)	2.2 (1.3–3.8)	0.54 (0.201–0.733)	0.08 (0.014–0.142)
Standard: German diabetic population (estimated)			44.9 (34.6–55.1)				

IRt, blindness incidence in total population; IRd, blindness incidence in population with diabetes; IRp, incidence of blindness in individuals with diabetes in total population; IRn, blindness in individuals without diabetes in population without diabetes; RR relative risk (IRd/IRn); ARE, individual attributable risk of diabetes among exposed; PAR, population attributable risk of diabetes.

acceptance procedure requires only written ophthalmological statements or additional medical statements. Most counties and cities in the earlier study region of Württemberg-Hohenzollern assess only ophthalmological statements, so the diabetes status is unknown. Thus, we could analyse only regions which are neighbouring to the former study regions. As a consequence, the observed reduction in the incidence of blindness may be attributable to differences between the regions. However, we can assume that the population within Baden-Württemberg is very similar: Based on our data, the overall incidence of blindness in the whole federal state of Baden-Württemberg, standardized to the 2008 German population was 9.6 (9.0–10.2). The overall incidence of blindness in our study region (22 counties and cities) was nearly equal, namely 9.7 (8.8–10.6). Mortality in Baden-Wuerttemberg seems not to differ in the various administrative districts [11]. One can assume that the lower incidences in the western areas, which were found in the present study, compared with the eastern areas, which were observed by Trautner et al. [3], do not stem from a comparison of sicker or healthier populations per se. Thus, we hypothesized that we could find a real reduction of the blindness risk.

We found lower incidences of blindness in the whole population compared with 1990. In Germany, a blindness register is lacking, so we do not have valid data about trends of the incidence of blindness [12]. However, most experts consider that the incidences of blindness are rising. But the considered increase may be attributable to the ageing of the population, whereas age-specific incidences may decline, for example, as a result of better early detection of glaucoma or the markedly increased cataract surgery [13,14]. This assumption is supported by the finding that regional incidence rates of blindness in Germany declined between 1980 and 1994 [14] and between 1991 and 1998 [2], and also by the observation that the proportion of cataracts and glaucoma or opticus atrophia as causes of blindness decreases, whereas the proportion of macular degeneration increases [12,15].

The question therefore is whether a reduction of blindness in the diabetic population is sign of a general improvement or can be attributed to an improvement in diabetes care. There may be several explanations for an improvement of the situation in the diabetic population. It is well documented that good metabolic control and early detection and treatment of diabetic retinopathy can reduce blindness [16,17]. In 2000, we found that blood glucose levels were within a good range in a high proportion of diabetic subjects [18] and the proportion of patients with regular eye examinations seems to have increased during the past years [19]. This improvement may be in part because of the implementation of disease management programmes for diabetes in Germany. Thus, both general and diabetes eye care may have improved.

Comparison with other studies

A comparison with study results from other countries is difficult, as definitions of legal blindness differ largely. In their review,

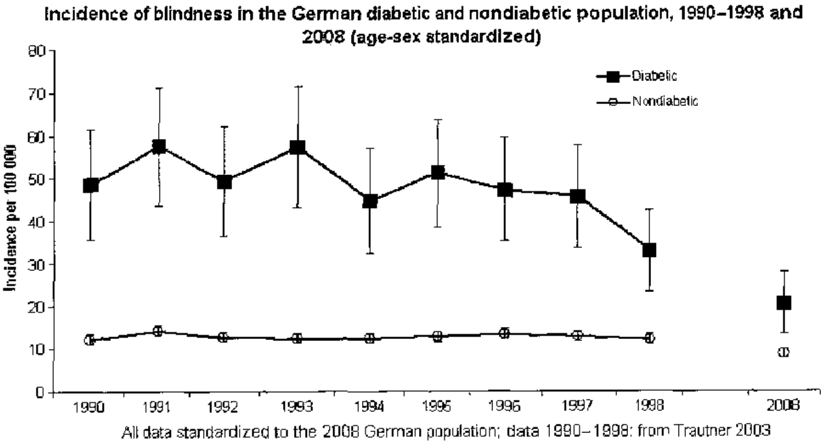

FIGURE 1 Incidence of blindness in the German diabetic (■) and non-diabetic (○) populations, 1990–1998 and 2008 (age and sex standardized). All data standardized to the 2008 German population; data 1990–1998 from Trautner *et al.* [3].

Hörle *et al.* state that the incidence of diabetes-related blindness in relation to diabetes mellitus in Western countries has remained approximately the same during 1992–2002 [20]. Also in Italy and Massachusetts, USA, the overall incidence of blindness did not change [21,22]. However, in men and women aged 20–44 years, the incidence of legal blindness caused by diabetes has been found to have decreased by approximately 29% [22]. A study from Sweden also showed a reduction for new blindness in diabetes by one third or more over the period 1981–1995 [23]. The following explanations are given: (i) improvement of diabetes education for patients during the past 15 years; (ii) a campaign intended to ensure regular eye examinations for all persons with diabetes since 1989; (iii) during the period 1991–1995 an increasing number of eye examinations, fluorescein angiography, laser photocoagulation, vitreous surgery and cataract extraction were performed [23].

Study limitations

Several limitations have to be considered. (i) The data are based on all newly registered blind persons in a limited geographic area during a certain period. There is no information about how many and which people do not apply for the blindness allowance even although they are entitled to. Furthermore, since 2005 the welfare authorities of municipalities are responsible for the blindness allowance procedure. Before 2005, the procedure was centralized in two state authorities. We cannot exclude that this change of responsibility influenced the acceptance of the blindness allowance. However, the procedure is legally based and has not changed during the past decades. Because of the amount of the blindness allowance, it can be expected that almost all incident cases are still recorded in this way. (ii) As discussed above, two neighbouring regions were analysed. Furthermore, we cannot exclude that the differences in the blindness incidence may be in part as a result of changes in socio-economic factors and/or migration. However, the two regions do not differ with respect to relevant health outcomes such as mortality. (iii) The results of our study are dependent on estimates of the number of diabetic subjects in the background population. As we do not have data on the diabetes prevalence in the study region, and no recent national diabetes prevalence data covering all age groups are available, we had to use data from the former register in Eastern Germany [6]. However, the diabetes prevalence in Germany has been shown to be stable between 1984 and 2006 [7,8]. Furthermore, a number of subjects are likely to have undiagnosed diabetes [24]. A misclassification would be more likely to lead to an underestimation of the relative risk.

The strength of the study is that we could evaluate incidence of blindness with a population-based approach in a large region. Despite the uncertainties mentioned above, we can have an overview of a long period where data were assessed using the same means.

In conclusion, we still found the incidence of blindness to be more than twofold higher in the diabetic compared with the non-diabetic population. Fifty-eight per cent of the risk to become blind in diabetic individuals and 9% of the risk to become blind in the entire population were attributable to diabetes. Incidences seem to be lower compared with the 1990s and this reduction may be similar or even more pronounced in the diabetic population. Overall, the reduction of the incidence of blindness may be substantial over the past two decades and this may be in part because of an improved diabetes care, as considered in the St Vincent declaration.

Author contributions

JG researched the data, contributed to the discussion and wrote the manuscript. MS analysed the data and contributed to the discussion. CT contributed to data analysis and discussion and reviewed/edited the manuscript. IZ contributed to the discussion and reviewed/edited the manuscript. GG contributed to the discussion and reviewed/edited the manuscript. AI conceptualized the study, contributed to data research, data analysis and discussion and wrote the manuscript.

Competing interests

Nothing to declare.

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