Markedly Decreasing Incidence of Blindness in People With and Without Diabetes in Southern Germany

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OBJECTIVE

Studies comparing the incidence of blindness in persons with and without diabetes are scarce worldwide. In Germany, a decline in the incidence of blindness was found during the 1990s. The aim of this study was to analyze the recent time trend.

RESEARCH DESIGN AND METHODS

Data were based on administrative files in southern Germany to assess recipients of blindness allowance newly registered between 1 January 2008 and 31 December 2012. We estimated age- and sex-standardized incidence of blindness in people with and people without diabetes and the corresponding relative risk. Poisson regression was used to examine age- and sex-adjusted time trends.

RESULTS

We identified 1,897 new cases of blindness (23.7% of which were associated with diabetes). We observed a strong decrease in incidence in both the population with diabetes (2008, 17.3 per 100,000 person-years [95% CI 13.6–21.1], and 2012, 8.9 per 100,000 person-years [6.3–11.6]: 16% decrease [10–22] per year) and that without diabetes (2008, 9.3 per 100,000 person-years [8.3–10.3], and 2012, 6.6 [5.8–7.4]: 9% decrease [5–13] per year). The relative risk comparing those incidences was 1.70 (95% CI 1.32–2.16) and remained constant in the observation period. Regarding time trend, we found similar results for both sexes.

CONCLUSIONS

We found a significant reduction in incidence of blindness in the populations with and without diabetes, which was more prominent among individuals with diabetes compared with the 1990s. Our findings may be explained by effective secondary prevention therapies and improved ophthalmologic care beyond diabetic retinopathy, particularly regarding macular degeneration, which means earlier detection and earlier and better treatment.

Diabetes is a highly prevalent chronic disease with the global prevalence of 8.8% among adults (20–79 years of age) in 2015 corresponding to 415 million people (1). Furthermore, diabetes can cause both macrovascular complications (stroke and peripheral and coronary artery disease) and microvascular complications such as diabetic nephropathy, neuropathy and retinopathy, which may lead to blindness. Thus, diabetes has been shown to be one of the leading causes of blindness in Western countries in the working-age population (2–5).

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The St. Vincent Declaration in Europe (1989) aimed to improve diabetes treatment and thus reduce the risk of diabetes-related blindness by one-third in 5 years (6). For analysis of any improvements, the collection of data on diabetes-related blindness was initiated at the beginning of the 1990s. Furthermore, the national German guidelines "Prevention and Therapy of Retinal Complications in Diabetes" aimed at an earlier detection of diabetic retinopathy, appropriate treatment, and the reduction of the incidence of blindness (7). However, surveillance for blindness among persons with diabetes has not been conducted nationally, and population-based data on incidence of blindness in the population with compared with the population without diabetes are scarce worldwide.

In our previous study covering the period 1990–1993 in two districts in Germany (parts of Baden-Württemberg and North Rhine-Westphalia), the incidence of blindness was found to be ~60.6 per 100,000 person-years in people with diabetes and 11.6 in the population without diabetes, resulting in a relative risk (RR) of 5.2 (8). In a subsequent study conducted in the same study area using data from 1990 to 1998, it was shown that the incidence of blindness decreased by 3% per year in the population with diabetes but remained constant among individuals without diabetes (6). Incidence of blindness was ascertained again in a study in 2008 covering neighboring parts of Baden-Württemberg showing that the RR of blindness between individuals with and individuals without diabetes decreased to the factor 2.4 (5). Approximately 59% of the risk of becoming blind in people with diabetes, and 9% of this risk in the entire population, was attributable to diabetes. The incidences were significantly lower compared with the earlier study in both the population with and the population without diabetes (8,9). The reduction of incidence in this study was more pronounced in the population with diabetes, where a significant decline had already been found during the period between 1990 and 1998 (9). However, the investigation of time trend was limited, since the regions were not exactly the same and we did not collect data between 1999 and 2007.

A significant decline in blindness incidence due to diabetes over approximately the same time span was also observed in Poland and Scotland (10,11). However, these studies did not adjust for age and sex, and no comparison with the population without diabetes was made. To the best of our knowledge, no studies have analyzed incidence of blindness in the population with or the population without diabetes except studies from Germany (3,5,9).

The aim of this study was to estimate the time trend of incidence rate (IR) of blindness in people with and people without diabetes in Germany and the corresponding relative and attributable risk over a 5-year period in a more recent timeframe. The study is part of a recent evaluation of late complications of diabetes according to the goals of the St. Vincent Declaration (6).

RESEARCH DESIGN AND METHODS

Database and Identification of Patients

We used the administrative files of the welfare administration (35 rural and 10 urban districts in the federal state of Baden-Württemberg, southern Germany) to assess all individuals who were newly registered as blindness allowance recipients between 1 January 2008 and 31 December 2012.

For our analysis, we included data from 22 of these 45 districts where a written medical statement was available that documented all relevant diseases, including diabetes. Of these 22 districts, we had to exclude 1 owing to incomplete data. In total, 1,903 new blindness allowance recipients were registered, of whom 6 had to be excluded owing to missing diabetes status.

Outcomes

A detailed description of the database and the blindness allowance procedure has previously been published (5). Briefly, all recipients of the blindness allowance were included who fulfilled the German criteria for blindness (visual acuity of 0.02 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 caused by, for example, central scotoma, making the person unable to find his or her way; or morphological correlates that explain the blindness) regardless of their income. Applying this approach, which was used in earlier studies (3–5,9), we therefore could expect an almost complete collection rate of newly blind subjects.

Population data were obtained by the Federal Office of Statistics (12). The total population in the study region as of 31 December 2010 was 4,823,570, which corresponds to approximately half of the entire population of Baden-Württemberg. The population with diabetes was estimated by applying the age- and sex-specific diabetes prevalence of the German Health Update (GEDA) surveys of 2009, 2010, and 2012 (13–15). With regard to the year 2008, we assumed that the diabetes prevalence was the same as in the year 2009, since the GEDA survey of 2009 had already started in July 2008. Regarding the year 2011, we used the arithmetic mean of the estimates in 2010 and 2012.

Statistical Analysis

We performed the main analyses for the entire population as well as separately for men and women. We estimated the population with diabetes in each stratum, defined by sex and age (≤30, 30–39, 40–49, 50–59, 60–69, 70–79, 80–89, and ≥90 years) by multiplying the study population with the estimated age- and sex-specific prevalence of diabetes. We calculated stratum-specific and directly standardized IRs of blindness with 95% CIs in the estimated population with and population without diabetes for each calendar year using the German population of 2010 as the standard population. Furthermore, we estimated IR ratio (IRR) as well as attributable risk of blindness comparing the population with versus without diabetes from the standardized IRs.

In order to examine time trends, we first fitted Poisson regression models with IR of blindness as the dependent variable and year of blindness as linear continuous difference from baseline year 2008 as the independent variable. These models were calculated separately for individuals with and without diabetes and were adjusted for age. The three lowest age classes (i.e., ≤30, 30–39, and 40–49 years) were combined into one group (≤50 years) because of convergence problems of some models and were therefore used as a reference group. Furthermore, we performed analogous Poisson models for the entire population. In these models, we additionally included a variable presence of diabetes ("yes" vs. "no") as well as an interaction term for diabetes and years since 2008.

All analyses were conducted with the descale adjustment to take into account overdispersion of the outcome variable, which was based on cumulated data

on the covariate strata year * sex * age class * diabetes. We performed analysis using the statistical analysis system SAS (SAS for Windows 7, release 9.4 TS1M1; SAS Institute, Cary, NC).

Ethics

The study was performed in accordance with the Declaration of Helsinki for research involving human subjects and the good epidemiological practice guideline (16).

RESULTS

Study Population

In our study region, we identified 1,897 new registered blindness allowance recipients in the years 2008–2012. The age- and sex-frequency distributions are shown in Table 1. Most of those with new cases of blindness were female (62.5%) and were >80 years of age (54.8%). Among persons without diabetes, ~8% were <30 years of age and 14% older than 90 years of age. In contrast, none were younger than 30 years of age among individuals with diabetes and solely 7% were >90 years of age (Supplementary Data). The age distribution remained nearly constant during the years 2008–2012, which was true in both groups: persons with and persons without diabetes (Supplementary Data). Almost one-quarter of those with new cases of registered blindness allowances were classified as having diabetes, with similar proportions in both sexes, which substantially decreased from 26.1% in 2008 to 20.7% in 2012. In contrast, the diabetes prevalence in the background population changed only marginally in the same time interval (2008, 7.1%, and 2012, 7.3%).

Incidence Rate and RR

The age- and sex-standardized IRs of blindness are presented in Table 2. We observed a strong decrease of IR per 100,000 person-years in the population with diabetes (2008, 17.3 [95% CI 13.6–21.1], and 2012, 8.9 [6.3–11.6]), with a particularly strong decrease in the first 3 years. Likewise, we found a somewhat weaker but still considerable decrease of IR in the population without diabetes (2008, 9.3 [8.3–10.3], and 2012, 6.6 [5.8–7.4]). In general, these results did not alter between sexes, with the exception that the decrease in the population with diabetes was somewhat stronger among women. The IRR comparing the incidence of blindness between persons with and persons without diabetes ranged between 1.3 (95% CI 1.0–1.7) in 2010 and 1.9 (1.5–2.4) in 2008. The attributable risk of blindness among the population with diabetes ranged between 0.24 (95% CI 0.01–0.42) and 0.46 (0.32–0.58), while the attributable risk of blindness in the total population lay between 0.03 (95% CI 0.00–0.12) and 0.10 (0.08–0.12).

Analysis of Time Trend and Other Covariates

The results of the incidence trend from the fully adjusted Poisson models are presented in Table 3. The RRs in the population stratified for diabetes status are shown in models 1a and 1b. We observed a significant decline in the blindness incidence in the population with diabetes during the observation period by 16% per year (RR per calendar year 0.84 [95% CI 0.78–0.90]). This decrease was seen in both sexes, with a somewhat stronger decline among women. The IR was ~20% lower among men compared with women (RR 0.80 [0.66–0.99]). The IR strongly increased with age among women but not among men.

When considering the population without diabetes, we observed a weaker albeit significant decrease in blindness incidence by 9% per year (RR 0.91 [95% CI 0.87–0.95]). No difference was seen between men and women, while this IR increases strongly with age.

When considering the entire population in model 2, we found a 70% increased IR in the population with diabetes compared with the population without diabetes (RR 1.70 [95% CI 1.32–2.16]) with comparable results in both sexes.

This difference was particularly strong among the younger age-groups and was even reversed in the oldest age-group (RR diabetes vs. no diabetes, age <50 years, 3.11 [95% CI 1.56–6.18]; 90+ years, 0.57 [0.36–0.88]) (data not shown). The interaction diabetes * calendar year was nonsignificant, indicating that the RR comparing the population with and without diabetes did not materially alter, which was true for both sexes.

CONCLUSIONS

Main Findings

We estimated IRs, RRs, and attributable risk of blindness comparing people with and without diabetes and their time trend in a large region in southern Germany between 2008 and 2012. We found a significant reduction in incidence of blindness in both the population with and that without diabetes, which was in particular strong between 2008 and 2010, with a somewhat stronger decline among individuals with diabetes. However, the risk of blindness remained significantly increased among individuals with diabetes compared with people without diabetes, with RR ranging between 1.3 and 1.9. We observed similar results in both sexes with regard to time trend.

Comparison With Other Studies and Implications

Compared with the 1990s, the regional IR of blindness in Germany markedly declined (17) (Fig. 1). This decrease was observed in both populations with diabetes (1990, 48.4 per 100,000 person-years [95% CI 35.3–61.4], and 2012, 17.3 per 100,000 person-years [13.6–21.1]) and without diabetes (1990, 12.2 per 100,000 person-years [11.1–13.4], and 2012, 6.6 per 100,000 person-years [5.8–7.4]), with a much more prominent decline in the population with diabetes, leading to a markedly reduced RR from 4.0 in 1990 to 1.4 in 2012 (5,9). Unfortunately, the study region of the analysis in the 1990s is not exactly the same as that in our study, but they are neighboring districts with a similar age distribution. The observed reduction at first seems surprising owing to the aging of the population. However, this decrease remained after age standardization. The substantial decrease in blindness due to diabetic retinopathy was already shown in Germany, which could be explained by several factors (e.g., improved treatment of diabetes, better collaboration between diabetologists and ophthalmologists, better ophthalmologic diagnostics and therapy for diabetic macula edema via optical coherence tomography, as well as intravitreal medication with vascular endothelial growth factor [VEGF] inhibitors or steroids) (18).

A possible explanation for the decrease in incidence in the population without but also with diabetes could be improved early detection and treatment of macular degeneration, the treatment of glaucoma, and markedly increased cataract surgery (19). A substantial reduction in blindness due to age-related macular degeneration, which is the main cause of blindness, in the previous two decades was observed in southern Germany (3). This finding was also confirmed by a

Table 1—Description of all persons with first blindness and the background population, Baden-Württemberg, 2008–2012

						Men		Women	
	Total	Men	Women	Diabetes	No diabetes	Diabetes*	No diabetes*	Diabetes*	No diabetes*
All years combined									
Persons with blindness†	1,897	712 (37.5)	1,185 (62.5)	449 (23.7)	1,448 (76.3)	167 (23.5)	545 (76.5)	282 (23.8)	903 (76.2)
Total person-years	24,027,101	11,780,875 (49.0)	12,246,226 (51.0)	1,748,049 (7.3)	22,279,052 (92.7)	827,861 (7.0)	10,953,014 (93.0)	11,326,038 (92.5)	920,188 (7.5)
Age at time of first blindness (years)									
≤30	121	61 (50.4)	60 (49.6)	0 (0.0)	121 (100.0)	0 (0.0)	61 (100.0)	0 (0.0)	60 (100.0)
30–39	40	24 (60.0)	16 (40.0)	3 (7.5)	37 (92.5)	3 (12.5)	21 (87.5)	0 (0.0)	16 (100.0)
40–49	64	35 (54.7)	29 (45.3)	11 (17.2)	53 (82.8)	9 (25.7)	26 (74.3)	2 (6.9)	27 (93.1)
50–59	115	56 (48.7)	59 (51.3)	41 (35.7)	74 (64.3)	22 (39.3)	34 (60.7)	19 (32.2)	40 (67.8)
60–69	149	74 (49.7)	75 (50.3)	54 (36.2)	95 (63.8)	26 (35.1)	48 (64.9)	28 (37.3)	47 (62.7)
70–79	369	162 (43.9)	207 (56.1)	107 (29.0)	262 (71.0)	44 (27.2)	118 (72.8)	63 (30.4)	144 (69.6)
80–89	807	247 (30.6)	560 (69.4)	202 (25.0)	605 (75.0)	60 (24.3)	187 (75.7)	142 (25.4)	418 (74.6)
≥90	232	53 (22.8)	179 (77.2)	31 (13.4)	201 (86.6)	3 (5.7)	50 (94.3)	28 (15.6)	151 (84.4)
Year of first blindness: 2008									
Persons with blindness†	467	174 (37.3)	293 (62.7)	122 (26.1)	345 (73.9)	46 (26.4)	128 (73.6)	76 (25.8)	217 (74.1)
Total population	4,816,006	2,358,576 (49.0)	2,457,430 (51.0)	344,252 (7.1)	4,471,754 (92.9)	158,955 (6.7)	2,199,621 (93.3)	185,297 (7.5)	2,272,133 (92.5)
Year of first blindness: 2009									
Persons with blindness†	404	140 (34.7)	264 (65.3)	104 (25.7)	300 (74.3)	29 (20.7)	111 (79.3)	75 (28.4)	189 (71.6)
Total population	4,816,733	2,360,698 (49.0)	2,456,035 (51.0)	349,195 (7.2)	4,467,538 (92.8)	162,004 (6.9)	2,198,694 (93.1)	187,191 (7.6)	2,268,844 (92.4)
Year of first blindness: 2010									
Persons with blindness†	388	143 (36.9)	245 (63.1)	84 (21.6)	304 (78.4)	31 (21.7)	112 (78.3)	53 (21.6)	192 (78.4)
Total population	4,823,570	2,367,327 (49.1)	2,456,243 (50.9)	352,908 (7.3)	4,470,662 (92.7)	170,451 (7.2)	2,196,876 (92.8)	182,457 (7.4)	2,273,786 (92.6)
Year of first blindness: 2011									
Persons with blindness†	314	130 (41.4)	184 (58.6)	72 (22.9)	242 (77.1)	32 (24.6)	98 (75.4)	40 (21.7)	144 (78.3)
Total population	4,838,304	2,378,244 (49.2)	2,460,060 (50.8)	355,568 (7.3)	4,482,736 (92.7)	171,466 (7.2)	2,206,778 (92.8)	184,102 (7.5)	2,275,958 (92.5)
Year of first blindness: 2012									
Persons with blindness†	324	125 (38.6)	199 (61.4)	67 (20.7)	257 (79.3)	29 (23.2)	96 (76.8)	38 (19.1)	161 (80.9)
Total population	4,732,488	2,316,030 (48.9)	2,416,458 (51.1)	346,126 (7.3)	4,386,362 (92.7)	164,985 (7.1)	2,151,045 (92.9)	181,141 (7.5)	2,235,317 (92.5)

Data are *n* or *n* (%). *Percentages related to total male population and female population, respectively. †Related to total population.

Table 2—Incidence of blindness, Germany, 2008–2012

	IR (95% CI) per 100,000 person-years*			IRRs and attributable risk (95% CI)		
	IRt	IRd	IRn	IRR	ARE	PAR
Total population						
2008	10.3 (9.4–11.3)	17.3 (13.6–21.1)	9.3 (8.3–10.3)	1.9 (1.5–2.4)	0.46 (0.32–0.58)	0.10 (0.08–0.12)
2009	8.7 (7.9–9.6)	14.3 (10.8–17.9)	7.8 (6.9–8.7)	1.8 (1.4–2.4)	0.45 (0.28–0.58)	0.10 (0.00–0.21)
2010	8.1 (7.3–9.0)	10.4 (7.8–13.0)	7.9 (7.0–8.8)	1.3 (1.0–1.7)	0.24 (0.01–0.42)	0.03 (0.00–0.12)
2011	6.4 (5.7–7.1)	10.8 (6.6–15.0)	6.0 (5.2–6.7)	1.8 (1.2–2.7)	0.45 (0.17–0.63)	0.06 (0.00–0.21)
2012	6.8 (6.1–7.6)	8.9 (6.3–11.6)	6.6 (5.8–7.4)	1.4 (1.0–1.9)	0.26 (0.00–0.46)	0.03 (0.00–0.16)
Male population						
2008	9.6 (8.1–11.0)	16.6 (10.6–22.5)	8.6 (7.0–10.1)	1.9 (1.3–2.9)	0.48 (0.23–0.65)	0.11 (0.08–0.14)
2009	7.3 (6.1–8.5)	11.7 (6.0–17.4)	7.0 (5.6–8.3)	1.7 (1.0–2.8)	0.41 (0.00–0.65)	0.05 (0.00–0.25)
2010	7.5 (6.2–8.7)	9.1 (5.6–12.7)	7.5 (6.1–9.0)	1.2 (0.8–1.9)	0.17 (0.00–0.47)	0.00 (0.00–0.16)
2011	6.6 (5.5–7.8)	13.3 (5.5–21.1)	6.2 (5.0–7.5)	2.1 (1.1–4.0)	0.53 (0.13–0.75)	0.06 (0.00–0.28)
2012	6.7 (5.5–7.9)	9.6 (5.3–14.0)	6.5 (5.1–7.8)	1.5 (0.9–2.5)	0.33 (0.00–0.59)	0.03 (0.00–0.24)
Female population						
2008	10.7 (9.5–11.9)	17.7 (12.9–22.5)	9.6 (8.3–10.9)	1.8 (1.4–2.5)	0.46 (0.26–0.60)	0.10 (0.08–0.13)
2009	9.4 (8.3–10.6)	15.5 (11.5–19.4)	8.2 (7.0–9.4)	1.9 (1.4–2.5)	0.47 (0.29–0.61)	0.13 (0.00–0.25)
2010	8.4 (7.4–9.5)	10.7 (7.1–14.3)	8.1 (6.9–9.2)	1.3 (0.9–1.9)	0.25 (0.00–0.48)	0.04 (0.00–0.15)
2011	6.3 (5.4–7.2)	8.2 (5.3–11.1)	5.9 (4.9–6.9)	1.4 (0.9–2.1)	0.28 (0.00–0.52)	0.06 (0.00–0.25)
2012	6.8 (5.9–7.8)	7.7 (4.9–10.5)	6.7 (5.7–7.8)	1.1 (0.8–1.7)	0.13 (0.00–0.42)	0.02 (0.00–0.19)

ARE, attributable risk of blindness in the population with diabetes; IRd, IR of blindness in individuals with diabetes in population with diabetes; IRn, IR of blindness in individuals without diabetes in population without diabetes; IRt, IR of blindness in total population; PAR, attributable risk of blindness in the total population. *Standardized to the German population, 2010.

Danish study indicating a decrease between 2000 and 2010, with a particularly strong decrease after 2006, when the intravitreal pharmacotherapy with inhibitors of VEGF therapy was introduced (20). The first indication of intravitreal anti-VEGF therapy in 2006 was the age-related macular degeneration. The indications of its use were extended to many pathologies,

Table 3—Results of Poisson models: RR for blindness, Germany 2008–2012

	RR (95% CI) for blindness‡		
Variables	Total population	Men	Women
Model 1a (population with diabetes)			
Calendar year	0.84 (0.78–0.90)*	0.88 (0.79–0.98)*	0.82 (0.77–0.87)*
Male vs. female	0.80 (0.66–0.99)*	—	—
Age (years)†			
≥90	17.52 (9.04–33.95)*	2.96 (0.84–10.49)	93.53 (31.02–281.99)*
80–89	19.58 (11.10–34.54)*	7.59 (4.08–14.11)*	90.45 (30.91–264.64)*
70–79	4.99 (2.78–8.94)*	2.01 (1.06–3.81)*	22.76 (7.71–67.22)*
60–69	3.22 (1.74–5.97)*	1.39 (0.70–2.76)	13.88 (4.60–41.85)*
50–59	3.09 (1.63–5.84)*	1.25 (0.62–2.53)*	14.12 (4.60–43.30)*
Model 1b (population without diabetes)			
Calendar year	0.91 (0.87–0.95)*	0.92 (0.86–0.98)*	0.91 (0.85–0.96)*
Male vs. female	0.94 (0.83–1.06)	—	—
Age (years)†			
≥90	94.60 (75.87–117.95)*	92.86 (64.29–134.12)*	97.76 (71.32–134.01)*
80–89	48.82 (40.84–58.35)*	44.15 (34.05–57.25)*	52.23 (39.82–68.52)*
70–79	10.10 (8.23–12.4)*	10.06 (7.56–13.40)*	10.21 (7.43–14.04)*
60–69	2.99 (2.27–3.93)*	3.11 (2.14–4.52)*	2.88 (1.87–4.45)*
50–59	1.64 (1.21–2.21)*	1.52 (1.00–2.33)*	1.75 (1.10–2.77)*
Model 2			
Calendar year	0.91 (0.86–0.96)*	0.92 (0.84–1.01)	0.91 (0.85–0.97)*
Diabetes (yes vs. no)	1.70 (1.32–2.16)*	1.66 (1.05–2.55)*	1.72 (1.27–2.30)*
Male vs. female	1.10 (0.97–1.26)	—	—
Age (years)†			
≥90	75.49 (57.79–98.63)*	63.36 (37.92–102.66)*	86.01 (61.32–121.84)*
80–89	44.99 (36.39–56.05)*	37.62 (26.94–53.14)*	51.75 (38.80–70.37)*
70–79	9.83 (7.75–12.53)*	8.91 (6.19–12.89)*	10.85 (7.81–15.26)*
60–69	3.61 (2.67–4.85)*	3.46 (2.20–5.35)*	3.78 (2.47–5.73)*
50–59	2.15 (1.55–2.95)*	1.96 (1.19–3.14)*	2.36 (1.49–3.67)*
Diabetes × calendar year	0.91 (0.82–1.02)	0.94 (0.78–1.14)	0.89 (0.78–1.02)

*$P < 0.05$. †Baseline: <50 years. ‡95% CI.

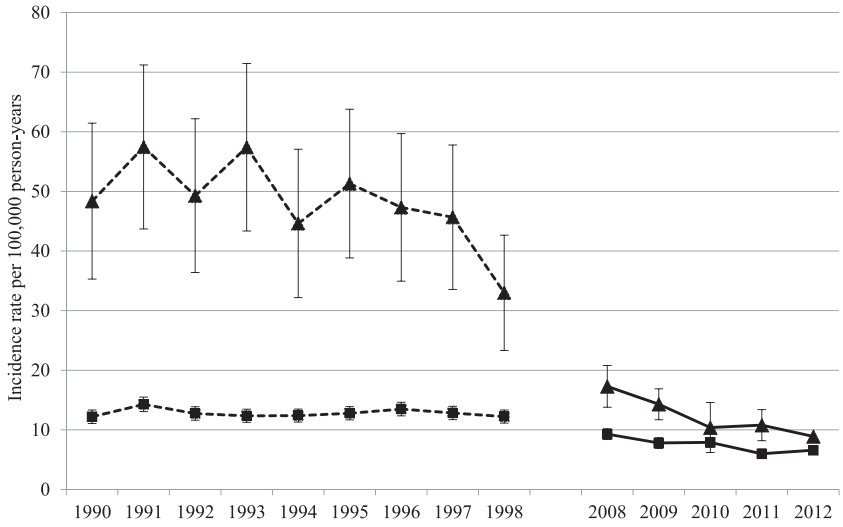

Figure 1—Time trend of age- and sex-standardized (standardized to the 2010 German population) incidence of blindness in the entire population and comparison with the previous examination. Black triangles, persons with diabetes; black squares, persons without diabetes; solid lines, study period of the recent examination analyzed in this study; dotted lines, study period of the previous examination.

and in the following years this treatment was established for patients with diabetic macular edema (ranibizumab in 2010 and aflibercept in 2014), retina vascular occlusion, and new vessels in pathologic myopia.

We found that the RR comparing persons with and persons without diabetes was higher among younger age-groups, with comparable results in both sexes. This result was in line with a previous study where the RR was increased among persons <60 years of age (5). This finding is not surprising, since with increasing age, risk of blindness strongly increased among persons without diabetes for other reasons (e.g., age-related macular degeneration, glaucoma). However, to the best of our knowledge no study found a significant decreased risk of blindness among persons with diabetes compared with those without diabetes among the elderly. A possible explanation could be that elderly persons with diabetes may be a selection of more healthy persons who survived, since mortality due to diabetes strongly increased in the study region in the elderly population (21). Furthermore, it could be assumed that the probability of a diabetes diagnosis rises strongly with age, leading to an increased denominator of incidence (11).

The definition of blindness is rather strict in Germany, making it difficult to compare incidences with other countries. Hall et al. (11) from Scotland showed a reduction for new blindness in the population with diabetes: the mean incidence of blindness attributable to diabetes was 42.7 per 100,000 person-years (95% CI 25–60) for 2000–2009 compared with 64.3 per 100,000 person-years for 1990–1999 (P = 0.062). The RR of developing blindness per year was 0.89 (95% CI 0.811–0.988; P = 0.028) for 2000–2009. The authors suggest that this may be a consequence of an increased denominator population, resulting from better recording of diabetes and changes to the diagnostic criteria. In Poland, the IR of blindness due to diabetes decreased significantly within the diabetic population from 102.4 per 100,000 (95% CI 65.7–139.0) in 1989 to 13.3 per 100,000 (3.8–24.9) in 2004 (10). However, the comparison of these studies is limited, since the IR was not adjusted for age or sex. Furthermore, no comparison with the IR in the population without diabetes was performed.

Limitations and Strengths

Several limitations have to be considered. Firstly, the considered districts of all analyses since the year 2008 were not exactly the same as the districts included in the analyses during the 1990s. Nevertheless, it was shown that the overall incidence of blindness was quite homogenous in this area (3). Secondly, 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 or which people do not apply for the blindness allowance even though they are entitled to. Thirdly, 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 rule out that this change of responsibility influenced the acceptance of the blindness allowance. Fourthly, it is known that diabetes prevalence increased as a result of improved and earlier detection of the disease, which leads to a less severely diseased population with diabetes, resulting in a decrease in incidence of blindness. However, we also observed a similar decrease between 2008 and 2012 in the population without diabetes. Finally, only extreme, severe cases of blindness could be considered in our data. Therefore, we cannot rule out that the incidence of less severe visual impairment remained constant or even increased.

One of the strengths of our study is that the procedure of blindness allowance was based by law on administrative files of the welfare administration and has not changed for decades. Because of the amount of the blindness allowance, it can be expected that almost all incident cases continue to be recorded in this way. Furthermore, we have—despite the uncertainties mentioned above—an overview of a long period in one region where data were assessed using the same means. Overall, the reduction in the incidence of blindness may be substantial over the past three decades, and this may in part be due to improved diabetes care, as considered in the St. Vincent Declaration.

We found a significant reduction in IR of blindness in both the population with and that without diabetes, which, compared with the 1990s, was particularly strong among individuals with diabetes. These findings may be explained by effective secondary prevention therapies and improved ophthalmologic care beyond diabetic retinopathy, in particular with regard to macular degeneration, which means earlier detection of the diseases.

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References

1. International Diabetes Federation. IDF Diabetes Atlas - 7th edition [Internet], 2015. Available from http://www.diabetesatlas.org/. Accessed 7 March 2016

2. Centers for Disease Control and Prevention. Blindness caused by diabetes–Massachusetts, 1987-1994. MMWR Morb Mortal Wkly Rep 1996;45:937–941

3. Claessen H, Genz J, Bertram B, et al. Evidence for a considerable decrease in total and cause-specific incidences of blindness in Germany. Eur J Epidemiol 2012;27:519–524

4. Trautner C, Haastert B, Richter B, Berger M, Giani G. Incidence of blindness in southern Germany due to glaucoma and degenerative conditions. Invest Ophthalmol Vis Sci 2003;44:1031–1034

5. Genz J, Scheer M, Trautner C, Zöllner I, Giani G, Icks A. Reduced incidence of blindness in relation to diabetes mellitus in southern Germany? Diabet Med 2010;27:1138–1143

6. Diabetes care and research in Europe: the Saint Vincent declaration. Diabet Med 1990;7:360

7. Bundesärztekammer (Federal Medical Council), AWMF (Association of the Scientific Medical Societies in Germany). Nationale VersorgungsLeitlinie – Prävention und Therapie von Netzhautkomplikationen. 2. Auflage, Version 1 [Internet], 2015. Available from http://www.awmf.org/uploads/tx_szleitlinien/nvl-001bk_S3_Netzhautkomplikationen_Typ-2-Diabetes_2016-12.pdf. Accessed 26 July 2017

8. Trautner C, Icks A, Haastert B, Plum F, Berger M. Incidence of blindness in relation to diabetes. A population-based study. Diabetes Care 1997;20:1147–1153

9. Trautner C, Haastert B, Giani G, Berger M. Incidence of blindness in southern Germany between 1990 and 1998. Diabetologia 2001;44:147–150

10. Bandurska-Stankiewicz E, Wiatr D. Diabetic blindness significantly reduced in the Warmia and Mazury Region of Poland: Saint Vincent Declaration targets achieved. Eur J Ophthalmol 2006;16:722–727

11. Hall HN, Chinn DJ, Sinclair A, Styles CJ. Epidemiology of blindness attributable to diabetes in Scotland: change over 20 years in a defined population. Diabet Med 2013;30:1349–1354

12. Federal Office of Statistics. List of links to the statistical offices of the Länder in Germany [Internet], 2016. Available from https://www.destatis.de/EN/PressServices/AddressBook/National.html. Accessed 7 March 2016

13. Robert Koch Institute. *German Health Update 2009 (GEDA 2009)*. Berlin, Robert Koch Institute, 2014 [in German]

14. Robert Koch Institute. *German Health Update 2010 (GEDA 2010)*. Berlin, Robert Koch Institute, 2013 [in German]

15. Robert Koch Institute. *German Health Update 2012 (GEDA 2012)*. Berlin, Robert Koch Institute, 2014 [in German]

16. Swart E, Gothe H, Geyer S, et al. [Good Practice of Secondary Data Analysis (GPS): guidelines and recommendations]. Gesundheitswesen 2015;77:120–126 [in German]

17. Knauer C, Pfeiffer N. [Blindness in Germany–today and in 2030]. Ophthalmologe 2006;103:735–741 [in German]

18. Bertram B, Gante C, Hilgers RD. [Age, sex and diagnostic distribution of patients in ophthalmological medical practice in Germany]. Dtsch Med Wochenschr 2012;137:1629–1634 [in German]

19. Hoffmeister L, Román R, Comas M, Cots F, Bernal-Delgado E, Castells X. Time-trend and variations in the proportion of second-eye cataract surgery. BMC Health Serv Res 2007;7:53

20. Bloch SB, Larsen M, Munch IC. Incidence of legal blindness from age-related macular degeneration in Denmark: year 2000 to 2010. Am J Ophthalmol 2012;153:209–213.e2

21. Baden-Wuerttemberg State Health Office. Age- and sex-specific mortalitly rates in Baden-Wuerttemberg 2010 [Internet], 2015. Available from https://www.gesundheitsamt-bw.de/SiteCollectionDocuments/03_Fachinformationen/Fachpublikationen+Info-Materialien/mortality_report_2010.pdf. Accessed 20 September 2016