Changes in visual impairment due to diabetic retinopathy during 1980–2019 based on nationwide register data

Diabetic retinopathy visual impairment 1980–2019

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Abstract

Objective: To evaluate changes in the incidence, prevalence, severity, and onset age of visual impairment (VI) due to diabetic retinopathy (DR) and compare these trends in the screening and treatment of diabetes during 40 years based on Finnish national register data.

Research Design and Methods: We included visually impaired persons with non-proliferative DR (NPDR; *n* = 2490, 73% females) or proliferative DR (PDR; *n* = 2026, 53% females) as the main diagnosis for VI during 1980–2019 in the Finnish Register of Visual Impairment. Number of treated diabetes patients during 1986–2019 was obtained from the Social Insurance Institution of Finland registers based on reimbursed medication data.

Results: Annual incidence of reported VI due to DR has decreased since it peaked in the 1990s: regarding NPDR, it decreased from 102.3 to 5.5 per 100 000 treated diabetes patients between the 1990s and 2010s; regarding PDR, respective change was from 39.9 to 7.4. The incidence of diabetes patients treated for DR increased during this period. Annual prevalence of reported VI and differences between sexes steadily decreased in the 2000s and 2010s. The severity of reported VI has decreased and the age at the onset of reported VI increased during the 40 years.

Conclusions: Prevalence and incidence of VI due to DR have dramatically decreased and shifted to older age during the 40 years despite the increasing prevalence of diabetes. These positive trends highlight the successful development and effectiveness of screening and therapies of diabetes and DR.

Introduction

Diabetic retinopathy (DR) is the leading cause of visual impairment (VI) and blindness among people of working age worldwide, but increasingly also among elderly people (1–4). It is classified into non-proliferative DR (NPDR) and proliferative DR (PDR). Both conditions are associated with the presence of diabetes. In 2015, the globally estimated number of persons with diabetes was 415 million, and by 2040, the projected figure is over 600 million (5).

In Europe, the prevalence of DR among diabetes patients is 25.7% (6). The prevalence of DR in persons with type 1 diabetes is 54.4%, whereas in persons with type 2 diabetes it is 25.0% (6). In 2010, the percentage of patients blinded by DR among blind persons was 3.9% in North America and 4.2% in Western Europe, and the percentage of patients with VI due to DR among visually impaired persons was 2.8% and 3.0%, respectively (7). In 2020, the estimated global prevalence of VI and blindness due to DR was 1.4% and 2.5%, respectively (8).

A significant number of type 2 diabetes patients consider loss of vision the worst complication of the disease (9,10). In fact, even mildly to moderately impaired vision has been associated with negative impact on quality of life and mental health due to fear of vulnerability and loss of independence, self-care, and mobility (11,12). As the number and life expectancy of persons living with diabetes increases in the future, the number of people with DR and consequently VI is expected to rapidly rise (3,13,14). Hence, there is a significant need for evaluating the changes in VI due to DR over time for public health issues and response.

While there are studies that have investigated the changes in the incidence and prevalence of VI due to DR in the past decades (13,15–21), these studies have usually

limited to small study samples, short follow-up periods, specific study regions, clinical trials, and/or specific VI or blindness classes. To our knowledge, comprehensive nationwide studies with long, 30–40-year follow-up periods have not been published before that would assess changes in VI due to DR and trends in the screening and treatment of the disease. A previous Finnish study investigated trends in VI due to DR during 1982–2010 based on Finnish national register data (4). In this study, we extended this investigation by providing a comprehensive overview of the temporal trends in VI due to DR during the past 40 years, a period in which many developments in the screening, diagnosis, and treatment of both diabetes and DR have occurred.

Research Design and Methods

The Finnish Register of Visual Impairment (The Finnish Federation of the Visually Impaired) is a national register regulated by the Act (556/89) and Decree (774/89) on National Personal Records kept under the Health Care System. Healthcare providers, specialists in ophthalmology, and the ophthalmological units of hospitals are, under the above-mentioned Act, responsible to submit information on persons with permanent VI to the register without need for permission from the patients. Between 1980 and 2019, the register included data on 58 822 visually impaired persons. Registered data include eye diagnoses, home region, date of birth and death, year of onset VI, and classification of VI. The time at the onset of VI is determined based on the notification data, and if it does not exist, the date of registration is used instead. VI is classified according to the Finnish definitions of VI using visual acuity (VA) and visual field (VF) from central fixation (22), which are based on the definitions of World Health Organization (23) with a modification of the nomenclature of the names of the VI classes: 1) mild VI ($0.3 > VA \geq 0.1$), 2) moderate VI ($0.1 > VA \geq 0.05$), 3) severe VI ($0.05 > VA \geq 0.02$; $10° > VF \geq 5°$), 4) near total blindness

(0.02 > VA – 1/∞; VF < 5°), and 5) total blindness (VA = 0; no sense of light). The classification of VI is updated if any further information is notified.

Our study population included visually impaired persons who had NPDR or PDR as the main diagnosis for VI based on the data of the Finnish Register of Visual Impairment. The classification of NPDR and PDR is based on the notification of the reporting ophthalmologist usually familiar with the patient's history of the eye disease.

We estimated the annual number of treated diabetes patients based on reimbursements for diabetes medication (data available 1986–2019) acquired from the Social Insurance Institution of Finland registers. To assess the changes in different diagnoses and therapies related to DR, we received annual number of patients diagnosed with type 1 or 2 diabetes and related eye complications (based on the codes E10, E10.3, E11, and E11.3 of the 10th version of International Classification of Diseases and Related Health Problems [ICD]) in Finland during 1998–2019 from the Care Registers for Social Welfare and Health Care kept by the Finnish Institute for Health and Welfare. However, the data on type 2 diabetes is an underestimation because the patients receiving treatment in public or private primary healthcare only were not registered in the Care Registers for Social Welfare and Health Care during the whole study period. Therefore, data on type 2 diabetes presents those complicated cases referred to special healthcare. Based on this diagnosis data, we evaluated the annual number of diabetes patients treated with endophotocoagulation of retina, vitreoretinal surgery, or intravitreal injections (based on the operation procedure codes of Finnish Hospital League 3623–3628, 3631, 3633, 3724, and the NOMESCO Classification for Surgical Procedures codes CKD40, CKD65, CKD91–95, and CKD05) in Finland during 1986–2019 from hospital data kept by the Finnish Institute for Health and Welfare. Diabetes patients diagnosed with wet type of age-related macular degeneration (based on the ICD code H35.31) were excluded from intravitreal injections data. The

annual population of Finland and the age-specific life expectancies of the general population were provided by Statistics Finland. At the end of 2019, the population of Finland was 5 525 292 (50.6% females).

This study was conducted in line with the tenets of the Helsinki Declaration. Because this is a register-based study, the approval of ethical committee is not required according to the Finnish legislation.

NPDR and PDR data were analyzed separately. Annual incidence and prevalence rates were calculated based on the number of treated diabetes patients or all inhabitants at the end of each year, stratified or adjusted for age and sex. We also calculated average annual rates on decade-basis. The expected number of years with VI was calculated by subtracting the mean age at the onset of reported VI from the mean age at death in each decade. Because the age data were left-skewed, Mann–Whitney *U* test was used for between-group comparisons and Kruskal–Wallis test for multiple comparisons, adjusted with Dunn–Bonferroni correction. Statistical differences in annual incidence and prevalence rates were calculated using linear regression when appropriate. Chi-squared test was used for decade-based rates. Fisher's exact test was used for comparing VI distribution. Two-tailed P values < 0.05 were considered statistically significant. All statistical analyses were performed using R software version 4.1.1 (R Core Team, Foundation for Statistical Computing, Vienna, Austria) with DescTools package version 0.99.43 (24).

Results

Between 1980 and 2019, the Finnish Register of Visual Impairment included 2490 persons (73.2% females) with reported VI due to NPDR and 2026 persons (52.9% females) due to PDR. Among registered females, NPDR was more common than PDR in the 1980s

(452/697, 64.8%), 1990s (922/1332, 69.2%), and 2000s (345/610, 56.6%), but in the 2010s PDR was the leading cause of VI (151/254, 59.4%). Among registered males, PDR was the leading cause of VI in all decades (198/316, 62.7%; 283/561, 50.4%; 292/491, 59.5%; 182/255, 71.4%). The percentage of mild VI due to NPDR and PDR increased during the 40 years, whereas the percentage of more severe VI classes decreased (Supplemental Table S1). There were no significant differences in the distribution of VI classes between sexes in any decade.

The incidence and prevalence of reported VI due to DR during the 40 years among treated diabetes patients are shown in Figure 1 and in total population in Supplemental Figure S1. The incidence of reported VI due to both NPDR and PDR peaked in the 1990s in both sexes. The age- and sex-adjusted annual incidence of reported VI due to NPDR decreased from 102.3 (95% confidence interval [CI] 84.0–120.6) per 100 000 treated diabetes patients in the 1990s to 5.5 (95% CI 2.9–8.1) in the 2010s ($P < 0.001$). For PDR, corresponding decrease was from 39.9 (95% CI 30.5–49.3) to 7.4 (95% CI 4.9–9.9; $P < 0.001$). In total population (per 1 000 000 inhabitants), respective changes in incidence were from 22.8 (95% CI 18.7–26.8) to 3.0 (95% CI 1.6–4.5; $P < 0.001$) regarding NPDR, and from 8.9 (95% CI 6.8–11.0) to 4.1 (95% CI 2.7–5.5; $P < 0.001$) regarding PDR. When incidences were observed for each year, the incidence of reported VI due to NPDR has gradually declined since 1996 and PDR since 2007 among treated diabetes patients and in total population. Females showed higher incidence of reported VI due to both NPDR and PDR in the 1980s and 1990s ($P < 0.001$), but the difference between sexes has not been significant since.

The prevalence of reported VI due to NPDR has steadily decreased since 1996 among treated diabetes patients and since 2000 in total population, and due to PDR since 1998 among treated diabetes patients and since 2007 in total population. Females showed

higher prevalence during the 40 years ($P < 0.001$) regarding NPDR, although the difference has become smaller in the 2010s. No significant difference was found between sexes regarding PDR.

The incidence of reported VI due to DR by age among treated diabetes patients is shown in Figure 2 and in total population in Supplemental Figure S2. These figures show a shift to older age during the 40 years. Between the 1980s and the 2010s, the highest incidence of reported VI due to NPDR shifted from age group 75–79 to 85+ in females and from age group 70–74 to 80–84 in males when compared to both treated diabetes patients and total population. Regarding PDR, the age shift was from 65–69 to 70–74 in females and 55–59 to 80–84 in males. This age shift is also demonstrated by a cumulative frequency of age at the onset of VI in Supplemental Figure S3.

The age at the onset of reported VI and death by decade of onset VI is shown in Figure 3 and more detailed in Supplemental Table S2. The mean age at the onset of reported VI due to NPDR and PDR increased significantly from the 1980s to the 2010s in both sexes. This increase was particularly noticeable in PDR with almost a 20-year increase in males. The mean age at death also increased significantly during the 40 years in both sexes. Females had significantly higher mean age at the onset of reported VI in all decades except in the 2010s regarding both NPDR and PDR, as well as higher mean age at death in all decades except in the 2010s regarding PDR.

There was no significant change in expected number of years with VI during the 40 years in neither NPDR nor PDR. However, the expected number of years with VI was significantly lower compared to the life expectancy of the general population at the age at the onset of reported VI in every decade ($P < 0.001$): regarding NPDR, the difference by each decade was 8.1, 5.8, 6.3, and 7.0 years in females, and 6.4, 6.1, 6.7, and 8.0 years

in males, respectively; regarding PDR, the difference was 19.7, 10.0, 11.9, and 13.5 years in females, and 21.1, 12.2, 10.9, and 11.9 years in males.

The annual prevalence of treated diabetes, incidence of diabetes and related eye complication diagnoses, and incidence of DR-related therapies are shown in Figure 4. The annual prevalence of treated diabetes patients per 100 000 inhabitants increased with each decade: 1890, 2225, 3180, and 5516. Incidence of persons diagnosed with type 1 diabetes per 100 000 inhabitants increased from 328 in 1998 to 480 in 2019. Incidence of persons diagnosed with eye complications due to type 1 diabetes per 100 000 inhabitants increased from 65 in 1998 to 160 in 2019, but regarding type 2 diabetes, the incidence was 84 in 1998 and has stayed relatively same since. When different DR-related treatments were observed, the incidence of diabetes patients treated with endophotocoagulation of retina and vitreoretinal surgery increased gradually during the 1980s and 1990s, and intravitreal injections particularly in the late 1990s. During the 2000s and 2010s these incidences have stayed relatively same or decreased among treated diabetes patients and in total population.

Conclusions

Here we have shown that both the incidence and prevalence of VI due to DR have significantly decreased since the peak years in the 1990s despite the increased prevalence of diagnosed and treated diabetes. Even though DR has been previously associated with working age population, a noticeable shift to older age has occurred during the 40 years. The severity of reported VI has decreased during the same time period. Differences between sexes have equalized in the 2000s and 2010s.

This study extended the previous report by Laatikainen et al. who observed increased age at the time of VI notification, decreased severity of VI due to DR, and higher age at death

in visually impaired persons during 1982–2010 (4). These improvements mostly occurred in the 1990s.

Our study shows that both the incidence and prevalence of VI due to DR increased gradually in the 1980s and 1990s. This is likely explained by the increased prevalence of diabetes in Finland since the 1980s (14,25,26). Furthermore, the Social Insurance Institution of Finland register data shows a three-fold increase in the prevalence of treated diabetes patients during the 40 years. However, the incidence and prevalence of VI due to DR started to decrease in the late 1990s.

The positive trends in the VI since the late 1990s are likely contributable to many factors. The treatment for diabetes was intensified in the late 1990s (27). In addition, Saramies et al. reported that the proportion of undiagnosed diabetes in Finnish population had decreased from 63% to 33% in 1996–2019 (14). Furthermore, based on a population-based study on Finnish adults, the increase in the prevalence of hyperglycemia in previous decades had stagnated in the 2010s (28). The screening and treatment of DR have also improved since the 1990s as indicated by the increased incidence of DR-related treatments among treated diabetes patients in our data. The national screening program was intensified by the use of regular and standardized photographic methods. Intravitreal injections of steroids and later in the 2000s anti-VEGF (vascular endothelial growth factor) improved the prognosis of diabetes patients (29,30). These, as well as timely laser therapy for DR and vitrectomy surgery for advanced DR, all contribute to the improved prevention of vision loss due to DR (2).

The changes in the incidence and prevalence of VI due to DR have considerably varied in previous studies, which have usually limited to small study populations, short follow-up periods, or specific region of study. In Sweden, Bäcklund et al. reported decreased incidence of blindness among diabetes patients by 47% during 1981–1995 based on

vision rehabilitation center data in Stockholm County (15). In Denmark, Hovind et al. demonstrated in a clinic-based follow-up study consisting of 600 type 1 diabetes patients during 1965–2000 that the VA was better in later cohorts than in earlier cohorts (16). In Wisconsin, USA, Klein et al. observed during a follow-up from 1980 to 2007 that the prevalence of VI was lower among persons with type 1 diabetes diagnosed in more recent years (19). In Ireland, based on a 10-year follow-up the incidence of VI due to DR among diagnosed diabetes patients registered in the National Council for the Blind of Ireland almost doubled between 2004 and 2013, whereas the incidence of blindness halved during the same period (20). In a systematic review of medical literature based on collected data from different countries between 1990 and 2010, Bourne et al. reported that the estimated blindness due to DR remained unchanged in various high-income countries (7). In a meta-analysis of global scale, DR showed an increase in an estimated age-standardized prevalence between 1990 and 2020 worldwide, even though other vision-threatening eye diseases such as age-related macular degeneration decreased (8). Therefore, even though DR shows positive trends in Finland and other high-income countries, it continues to be a significant cause of VI worldwide.

The incidence of VI due to DR showed a shift to older age during the 40 years. This is further supported by the increased age at the onset of VI. This age shift is at least partly explained by the increasing prevalence of type 2 diabetes, which is more common among older people than type 1 diabetes in Finland, and the prevalence is likely to keep increasing due to the ageing of population and increase of overweight and obesity in the population (26). As the treatment of diabetes and DR has improved and the life expectancy of diabetes patients increased, VI is more likely to occur at later age among other age-associated vision-threatening diseases.

We reported that both the incidence and prevalence of VI due to DR were higher in females in the 1980s and 1990s, but these differences have equalized in the 2000s and 2010s. This could be explained by the declining share of females among diabetes patients that was observed during 1997–2007 in Finland (26). In global scale, the estimated prevalence of VI and blindness due to DR in 2020 was still higher in women (8).

The decline in the severity of VI due to DR during the past decades as shown in this study is likely associated with the declined rate of VI among diabetes patients reported in previous studies. In Iceland, the proportion of legally blind diabetes patients decreased from 2.4% in 1980 to 0.5% in 2005 (31,32). In Wisconsin, USA, the estimated annual rate of any VI among patients with early onset type 1 diabetes decreased from 1.2 in the 1980s to 0.3 in the early 2000s (33). They suggested that better glycemic and blood pressure control, as well as avoidance of smoking likely contribute to these trends.

Even though the age at death has increased among DR patients during the 40 years, our data shows that in the 2010s the life expectancy among persons with VI due to NPDR was still seven years shorter and due to PDR ten years shorter than in the general population. Similarly, Laatikainen et al. reported that the standardized mortality ratios decreased among patients with VI due to DR between the 1980s and the 2000s, yet the mortality is still greater than in the general population (4). These adverse trends are likely attributable to the shorter life expectancy associated with diabetes, as diabetes patients have increased risk of life-threatening systemic vascular complications, such as stroke and heart failure (2,34).

All in all, these trends reflect the improvement and efficiency of the screening and treatment of DR during the past 40 years. Nevertheless, patients with DR are still at the risk of VI and blindness. VA may not always improve above the mild vision loss level and some patients with long-standing DR may end up becoming blind due to neuroretinal and

pigment epithelial atrophy (35). Furthermore, the prognosis of treatment worsens the later the treatment begins during the course of DR (21). de Fine Olivarius et al. reported that a significant vision loss can occur during six years after diabetes diagnosis (36). Diabetes patients also have increased risk of other vision-threatening diseases, such as cataract and glaucoma (37). Hence, there is still a significant need to maintain and improve public awareness of vision-threatening complications of diabetes, as well as systematic screening, early diagnosis, and prompt treatment of DR to reduce the magnitude of VI and blindness in diabetes patients.

The strengths of our study include the large data set based on routinely collected health registers ensuring that our results are generalizable to population-level and comparable with those from studies in the other Western countries. The use of different registers made it possible to provide a comprehensive overview of changes in both DR and diabetes. In fact, the prevalence of diabetes in Finland is considered similar regardless of the data source (38). We had a unique opportunity to evaluate changes during a long, 40-year follow-up. The classification of VI is based on the Finnish national definitions and recommendations modified from the 1973 definitions by World Health Organization that cover both decreased visual acuity and visual field constriction. These criteria have remained same during the entire 40-year period to ensure compatibility between decades and the quality of the register data has been carefully followed. Therefore, the changes in the prevalence and incidence of VI caused by DR are likely to not reflect the changes in the notification methods.

Our study also has limitations. The reimbursement data for diabetes medicine does not cover diabetes patients with diet treatment or persons diagnosed while institutionalized. Hence, the prevalence of treated diabetes persons is not equivalent to the prevalence of diabetes, although we tried to improve the coverage of diabetes by providing diagnosis

data from the Care Registers for Social Welfare and Health Care. Furthermore, in most cases, diabetes with diet treatment or without related medication is relatively mild and usually does not cause retinal complications (unpublished results from Savitaipale study; 14). In 2017, the estimated number of diabetes patients was 429 000 in the Finnish population aged 30 years and older, of which 48 000 (11.2%) were undiagnosed (28). Nevertheless, in most cases, the hidden diabetes form is also relatively mild and is not causing diabetic retinal complications at the time of diagnosis. We could not cover the patients treated with laser treatments for DR as outpatients due to the development of the Care Registers for Social Welfare and Health Care during the first decades of the study. Also, the Current Care Recommendations in the Finnish Health care have changed the practices of the doctors during the study period. As register data in general, the VI register data can have potential sources of biases, although not as remarkable as those in diabetes detection. These include difficulties in the estimation of the exact time point at which a person has become visually impaired and when the disease itself has emerged, as well as the potential impact of other vision-threatening diseases. However, to minimize this bias, we analyzed only those patients whose main diagnosis causing VI was DR. The register may also lack information on specific populations, such as institutionalized demented persons. Our data included predominantly people with Finnish background; therefore, the results may not be directly applicable to other countries and ethnicities.

In conclusion, the incidence and prevalence of VI due to DR showed a gradual increase during the 1980s and 1990s but have since dramatically decreased despite the ever-increasing prevalence of diabetes. The severity of VI due to DR has decreased during the 40 years and differences between sexes equalized. Furthermore, the age at the onset of VI and age at death have increased in DR patients during the same period. These positive and encouraging trends underline the importance of efficient screening and timely

treatment of diabetes and DR. In future, more population-based studies with long follow-up periods in other countries could explore the situation in different regions of the world.

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Authorship

P.K.M.P, M.U.I.O, and M.G investigated the data. P.K.M.P conducted the statistical analysis. P.K.M.P and H.M.T.U wrote the manuscript. M.U.I.O and M.G. reviewed the manuscript and contributed to discussion. P.K.M.P is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Figure legends

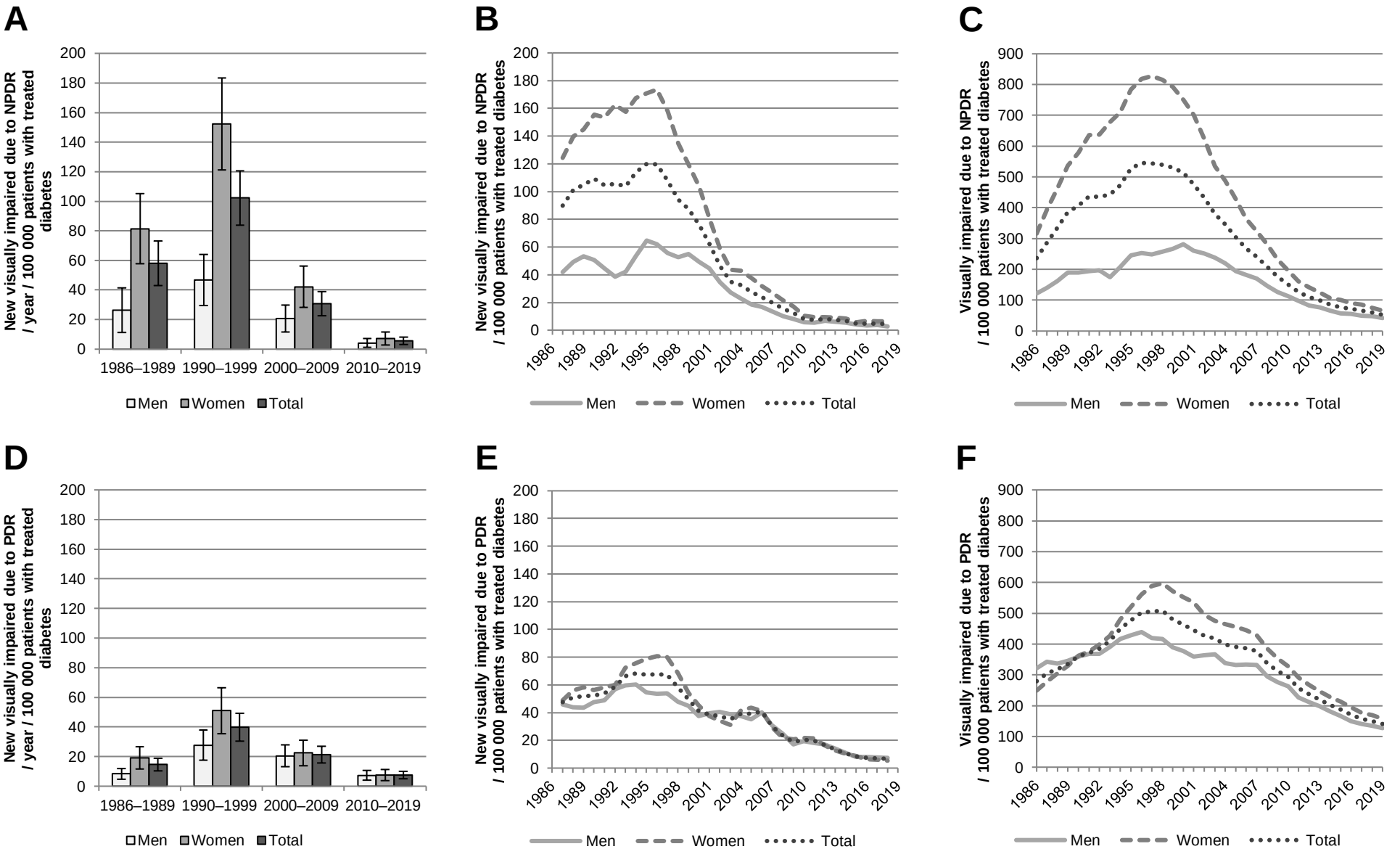
Figure 1—Reported visual impairment due to non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) among treated diabetes patients during 1980–2019. A. Average annual incidence of reported visual impairment due to NPDR per decade adjusted for age and/or sex (with 95% confidence intervals). B. Annual incidence of reported visual impairment due to NPDR smoothed using a three-year central moving average. C. Annual prevalence of reported visual impairment due to NPDR. D. Average annual incidence of reported visual impairment due to PDR per decade adjusted for age and/or sex (with 95% confidence intervals). E. Annual incidence of reported visual

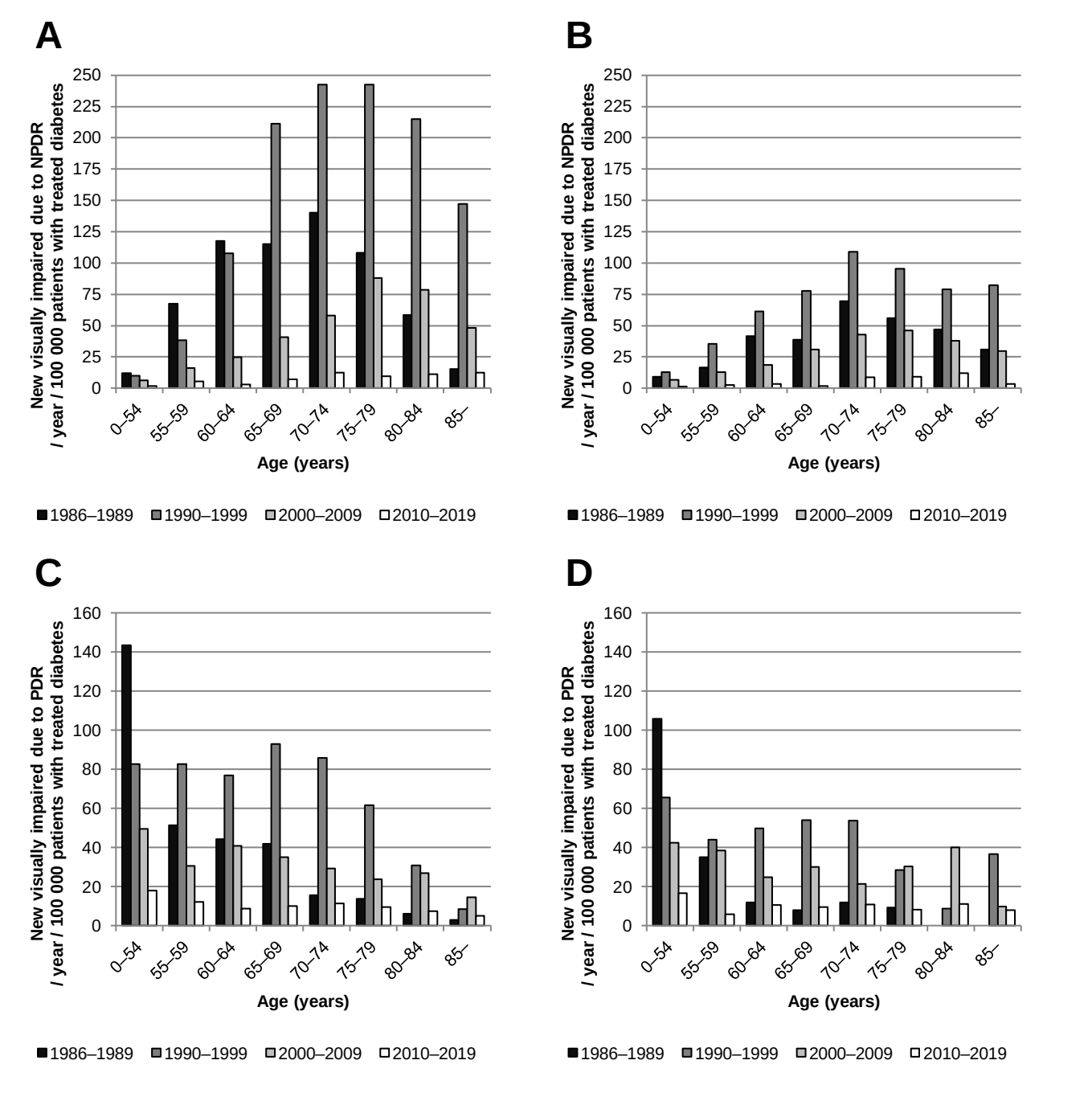
impairment due to PDR smoothed using a three-year central moving average. F. Annual prevalence of reported visual impairment due to PDR.

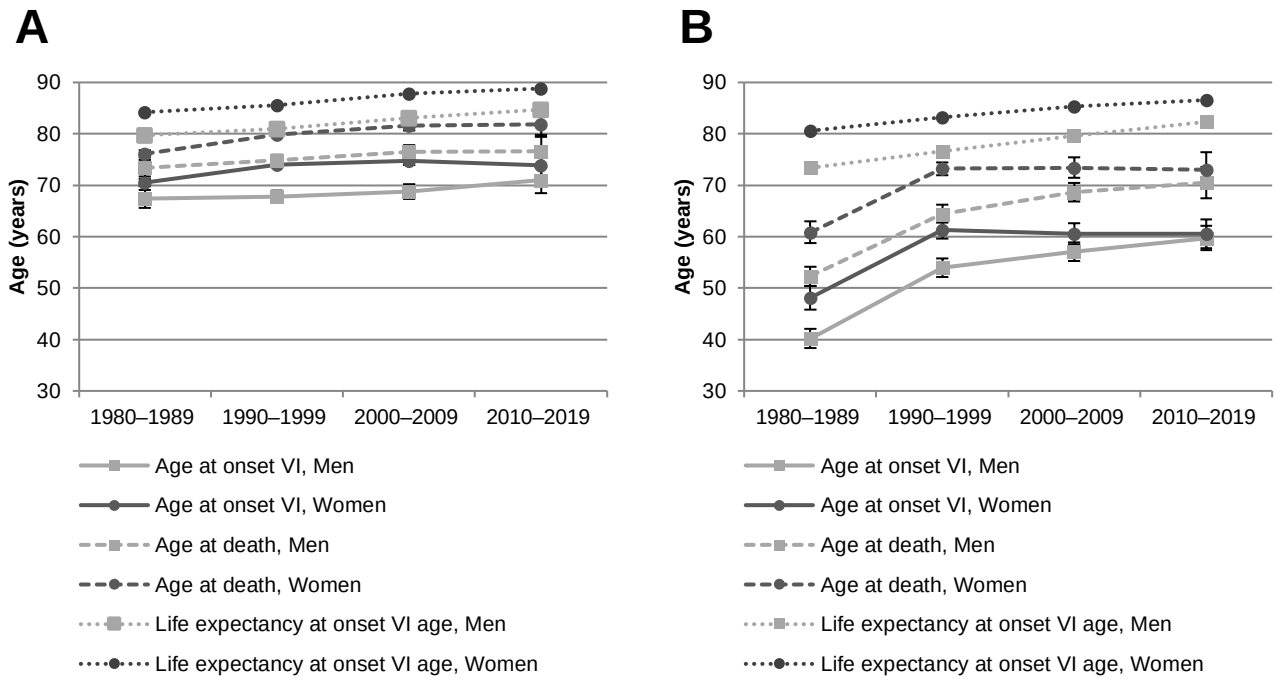
Figure 2—Average annual incidence of reported visual impairment due to non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) per decade among treated diabetes patients by age. A. NPDR, females. B. NPDR, males. C. PDR, females. D. PDR, males.

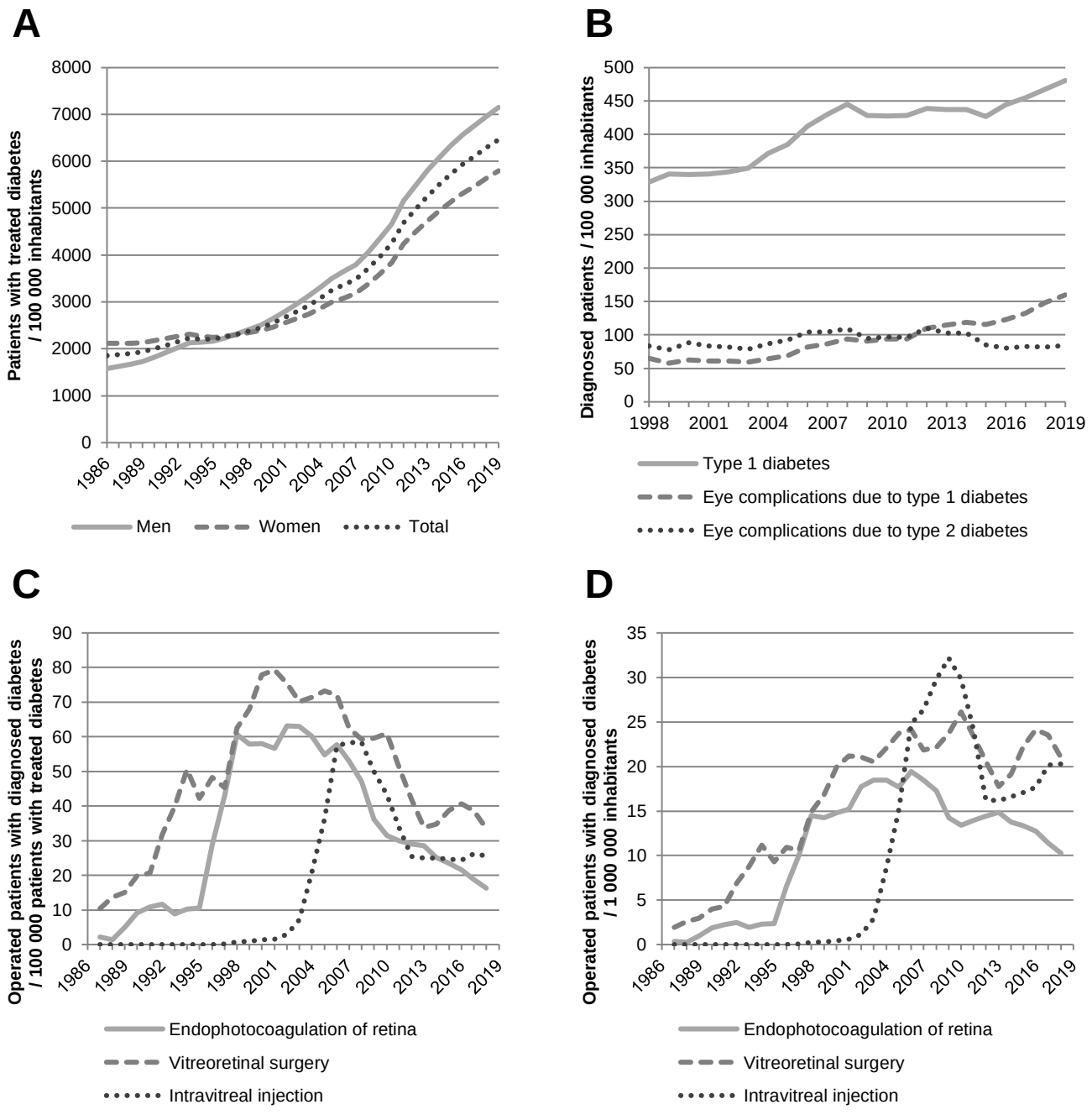
Figure 3—Age at the onset of reported visual impairment (VI) due to non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) and age at death with 95% confidence intervals by decade of onset. A. NPDR. B. PDR. For comparison, the life expectancy of the general population at the age of onset VI is shown.

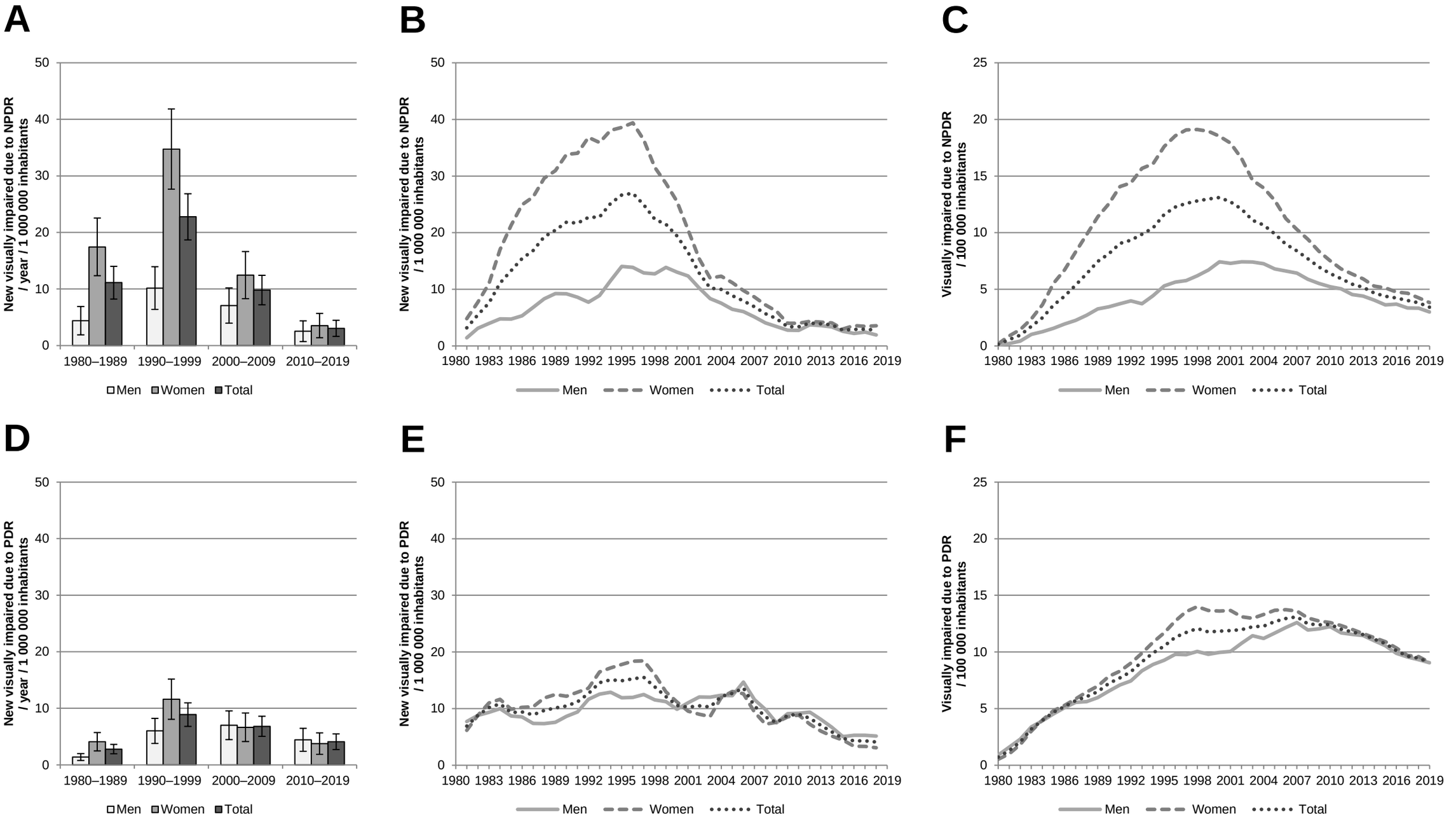
Figure 4—Trends in diabetes diagnoses and treatment for diabetic retinopathy. A. Annual prevalence of treated diabetes patients in total population during 1986–2019. B. Annual incidence of persons diagnosed with diabetes and related eye complications in total population during 1998–2019. C. Annual incidence of operated persons with diagnosed diabetes among treated diabetes patients during 1986–2019 smoothed using a three-year central moving average. D. Annual incidence of operated persons with diagnosed diabetes in total population during 1986–2019 smoothed using a three-year central moving average.


A
New visually impaired due to NPDR / year / 100 000 patients with treated diabetes
200
180
160
140
120
100
80
60
40
20
0
1986–1989
1990–1999
2000–2009
2010–2019
Men
Women
Total
B
New visually impaired due to NPDR / 100 000 patients with treated diabetes
200
180
160
140
120
100
80
60
40
20
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Men
Women
Total
C
Visually impaired due to NPDR / 100 000 patients with treated diabetes
900
800
700
600
500
400
300
200
100
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Men
Women
Total
D
New visually impaired due to PDR / year / 100 000 patients with treated diabetes
200
180
160
140
120
100
80
60
40
20
0
1986–1989
1990–1999
2000–2009
2010–2019
Men
Women
Total
E
New visually impaired due to PDR / 100 000 patients with treated diabetes
200
180
160
140
120
100
80
60
40
20
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Men
Women
Total
F
Visually impaired due to PDR / 100 000 patients with treated diabetes
900
800
700
600
500
400
300
200
100
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Men
Women
Total

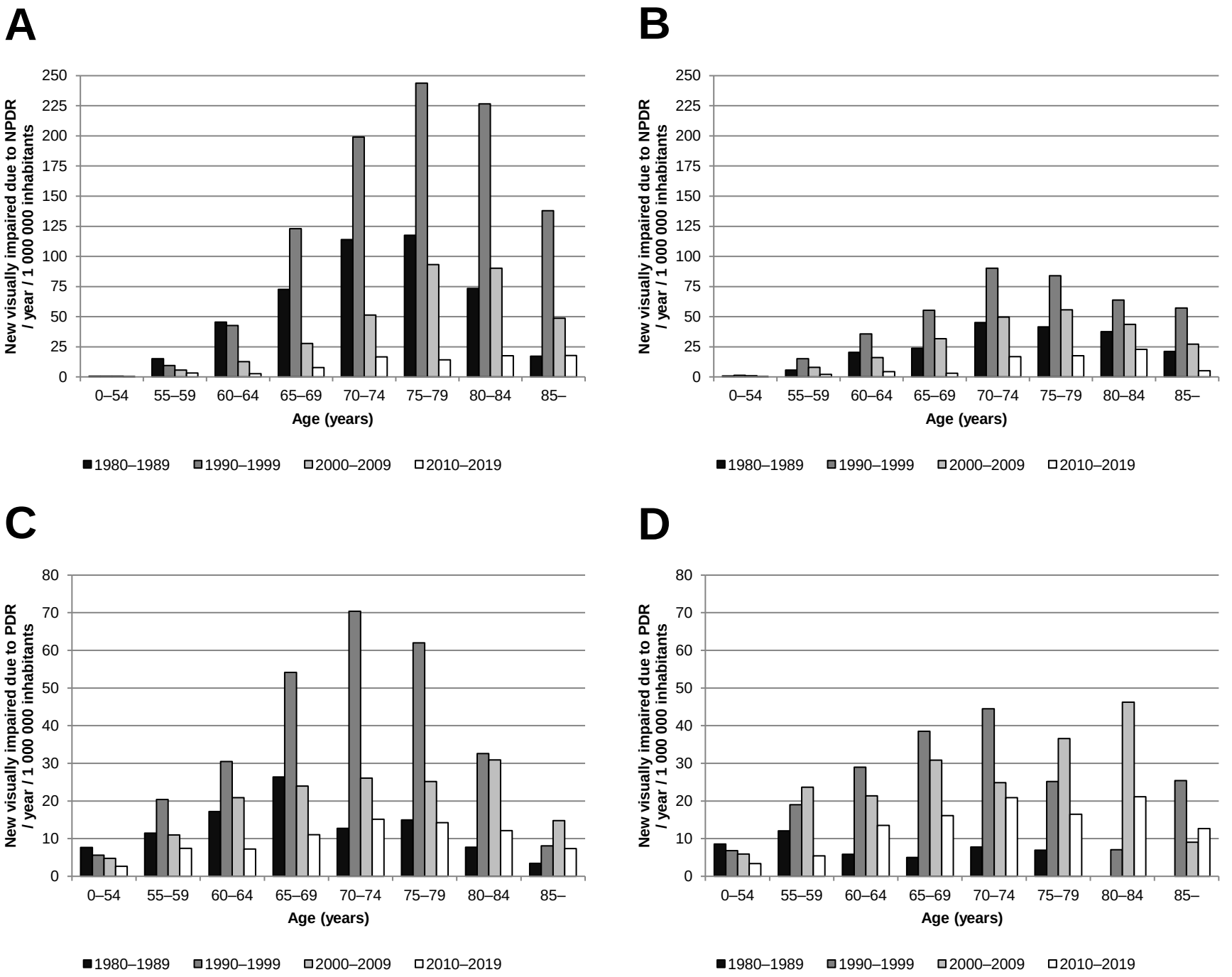

A
B
C
D
New visually impaired due to NPDR / year / 100 000 patients with treated diabetes
New visually impaired due to PDR / year / 100 000 patients with treated diabetes
0
25
50
75
100
125
150
175
200
225
250
0
20
40
60
80
100
120
140
160
0–54
55–59
60–64
65–69
70–74
75–79
80–84
85–
Age (years)
1986–1989
1990–1999
2000–2009
2010–2019


A
B
Age (years)
90
80
70
60
50
40
30
1980–1989
1990–1999
2000–2009
2010–2019
Age at onset VI, Men
Age at onset VI, Women
Age at death, Men
Age at death, Women
Life expectancy at onset VI age, Men
Life expectancy at onset VI age, Women

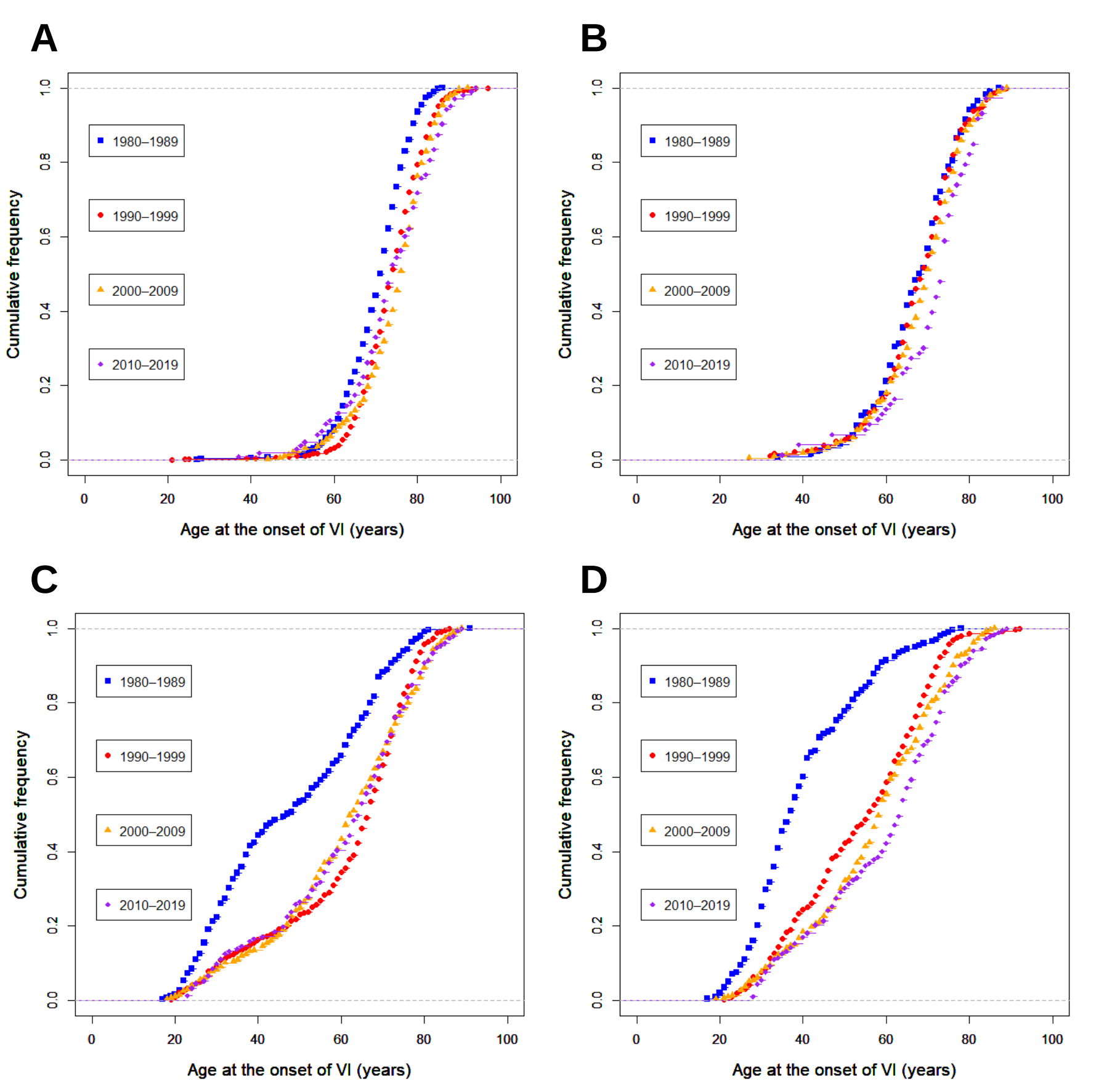

A
Patients with treated diabetes / 100 000 inhabitants
8000
7000
6000
5000
4000
3000
2000
1000
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Men
Women
Total
B
Diagnosed patients / 100 000 inhabitants
500
450
400
350
300
250
200
150
100
50
0
1998
2001
2004
2007
2010
2013
2016
2019
Type 1 diabetes
Eye complications due to type 1 diabetes
Eye complications due to type 2 diabetes
C
Operated patients with diagnosed diabetes / 100 000 patients with treated diabetes
90
80
70
60
50
40
30
20
10
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Endophotocoagulation of retina
Vitreoretinal surgery
Intravitreal injection
D
Operated patients with diagnosed diabetes / 1 000 000 inhabitants
35
30
25
20
15
10
5
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Endophotocoagulation of retina
Vitreoretinal surgery
Intravitreal injection



Supplemental Figure S1—Reported visual impairment due to nonproliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) in total population during 1980–2019. A. Average annual incidence of reported visual impairment due to NPDR per decade adjusted for age and/or sex (with 95% confidence intervals). B. Annual incidence of reported visual impairment due to NPDR smoothed using a three-year central moving average. C. Annual prevalence of reported visual impairment due to NPDR. D. Average annual incidence of reported visual impairment due to PDR per decade adjusted for age and/or sex (with 95% confidence intervals). E. Annual incidence of reported visual impairment due to PDR smoothed using a three-year central moving average. F. Annual prevalence of reported visual impairment due to PDR.



Supplemental Figure S2—Average annual incidence of reported visual impairment due to nonproliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) per decade in total population by age. A. NPDR, women. B. NPDR, men. C. PDR, women. D. PDR, men.



Supplemental Figure S3—Cumulative frequency of age at the onset of reported visual impairment (VI) due to nonproliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) by decade of onset. A. NPDR, women. B. NPDR, men. C. PDR, women. D. PDR, men.

Supplemental Table S1—Distribution of reported visual impairment due to nonproliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) by decade of onset

	1980–1989	1990–1999	2000–2009	2010–2019	*P* (decade difference)
NPDR, women					
Mild visual impairment	70.5%	74.5%	84.3%	87.0%	0.29
Moderate visual impairment	18.3%	16.3%	11.8%	9.0%	0.060
Severe visual impairment	10.3%	6.3%	3.6%	4.0%	0.004
Near total blindness	0.9%	2.7%	0.3%	0%	0.005
Total blindness	0%	0.2%	0%	0%	1
NPDR, men					
Mild visual impairment	77.1%	76.8%	85.5%	83.8%	0.87
Moderate visual impairment	12.7%	15.2%	10.4%	14.7%	0.59
Severe visual impairment	7.6%	6.5%	2.6%	1.5%	0.09
Near total blindness	2.6%	1.5%	1.5%	0%	0.71
Total blindness	0%	0%	0%	0%	1
P (sex difference)	0.16	0.76	0.39	0.36	
PDR, women					
Mild visual impairment	42.5%	64.1%	66.0%	68.5%	0.009
Moderate visual impairment	16.3%	16.2%	19.7%	14.0%	0.64
Severe visual impairment	11.2%	9.4%	8.1%	7.7%	0.68
Near total blindness	16.2%	9.6%	5.4%	8.4%	0.004
Total blindness	13.8%	0.7%	0.8%	1.4%	< 0.001
PDR, men					
Mild visual impairment	46.4%	62.7%	69.5%	73.1%	0.035
Moderate visual impairment	12.9%	18.3%	14.7%	8.2%	0.066
Severe visual impairment	10.8%	6.4%	8.1%	11.1%	0.29
Near total blindness	20.6%	9.7%	6.7%	5.8%	< 0.001
Total blindness	9.3%	2.9%	1.0%	1.8%	< 0.001
P (sex difference)	0.39	0.15	0.61	0.35	

Statistical significance was calculated using Fisher's exact test.

Supplemental Table S2—Mean age at the onset of reported visual impairment due to nonproliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) and age at death by decade of onset

	1980–1989	1990–1999	2000–2009	2010–2019	*P* (1980s vs. 2010s)
Age at onset VI, NPDR					
Women, *n*	452	922	345	103	
Women, years (95% CI)	70.5 (69.8–71.2)	74.0 (73.5–74.5)	74.8 (73.9–75.7)	73.8 (71.8–75.9)	< 0.001
Men, *n*	118	278	199	73	
Men, years (95% CI)	67.4 (65.6–69.1)	67.8 (66.6–69.0)	68.8 (67.4–70.3)	71.0 (68.5–73.5)	0.009
P (sex difference)	0.001	< 0.001	< 0.001	0.15	
Age at onset VI, PDR					
Women, *n*	245	410	265	151	
Women, years (95% CI)	48.1 (45.8–50.4)	61.3 (59.7–62.9)	60.6 (58.5–62.6)	60.6 (57.8–63.4)	< 0.001
Men, *n*	198	283	292	182	
Men, years (95% CI)	40.2 (38.4–42.1)	53.9 (52.1–55.8)	57.0 (55.2–58.9)	59.7 (57.4–62.1)	< 0.001
P (sex difference)	< 0.001	< 0.001	0.004	0.52	
Age at death, NPDR					
Women, *n*	451	914	309	44	
Women, years (95% CI)	76.1 (75.4–76.8)	79.8 (79.3–80.3)	81.6 (80.7–82.5)	81.8 (79.4–84.2)	< 0.001
Men, *n*	118	267	173	34	
Men, years (95% CI)	73.3 (71.7–75.0)	74.9 (73.8–75.9)	76.5 (75.1–77.8)	76.6 (73.4–79.8)	0.007
P (sex difference)	0.002	< 0.001	< 0.001	0.006	
Age at death, PDR					
Women, *n*	215	357	191	59	
Women, years (95% CI)	60.9 (58.7–63.0)	73.2 (72.0–74.4)	73.4 (71.4–75.4)	73.1 (69.6–76.5)	< 0.001
Men, *n*	185	248	208	72	
Men, years (95% CI)	52.3 (50.4–54.2)	64.4 (62.7–66.2)	68.6 (66.8–70.4)	70.5 (67.4–73.5)	< 0.001
P (sex difference)	< 0.001	< 0.001	< 0.001	0.21	

Statistical significance was calculated using Mann–Whitney *U* test. CI, confidence interval.