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Title	Trends in blindness due to diabetic retinopathy among adults aged 18-69 years over a decade in Ireland
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Publication date	2016-08-30
Original Citation	Tracey, M.L., McHugh, S.M., Fitzgerald, A.P., Buckley, C.M., Canavan, R.J. and Kearney, P.M. (2016) 'Trends in blindness due to diabetic retinopathy among adults aged 18–69 years over a decade in Ireland', Diabetes Research and Clinical Practice, 121, pp.1-8. doi: 10.1016/j.diabres.2016.08.016
Type of publication	Article (peer-reviewed)
Link to publisher's version	10.1016/j.diabres.2016.08.016
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Download date	2026-10-09 11:42:05
Item downloaded from	https://hdl.handle.net/10468/3143

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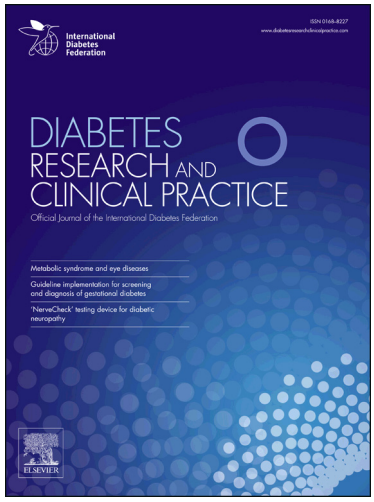

Trends in blindness due to diabetic retinopathy among adults aged 18-69 years over a decade in Ireland

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PII: S0168-8227(16)30453-3
DOI: http://dx.doi.org/10.1016/j.diabres.2016.08.016
Reference: DIAB 6731

To appear in: *Diabetes Research and Clinical Practice*

Received Date: 20 January 2016
Revised Date: 27 July 2016
Accepted Date: 19 August 2016

Please cite this article as: M .L. Tracey, S.M. McHugh, A.P. Fitzgerald, C.M. Buckley, R.J. Canavan, P.M. Kearney, Trends in blindness due to diabetic retinopathy among adults aged 18-69 years over a decade in Ireland, *Diabetes Research and Clinical Practice* (2016), doi: http://dx.doi.org/10.1016/j.diabres.2016.08.016

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Title page

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Structured abstract

Aims: To describe trends in the incidence of visual impairment and blindness due to diabetic retinopathy among adults aged 18-69 years in Ireland between 2004 and 2013.

Methods: Data on visual impairment due to diabetic retinopathy in adults aged 18-69 years or over who are registered with the National Council for the Blind of Ireland, (2004-2013) were analysed. Annual incidence rates were calculated for the adult population and the population with diagnosed diabetes. Poisson regression was used to test for changes in rates over time. The relative, attributable and population risk of blindness and visual impairment due to diabetic retinopathy were calculated for 2013.

Results: Over the decade, the prevalence of diagnosed diabetes increased from 2.1% to 3.6%. Among people with diagnosed diabetes, the incidence of visual impairment due to diabetic retinopathy increased from 6.4 (95% CI 2.4-13.9) per 100,000 in 2004 to 11.7 (95% CI 5.9-21.0) per 100,000 in 2013. The incidence of blindness due to diabetic retinopathy varied from 31.9 per 100,000 (95% CI 21.6-45.7) in 2004 to 14.9 per 100,000 (95% CI 8.2-25.1) in 2013.

Conclusions: Our findings indicate the need for increased attention to preventive measures for microvascular complications among adults with diabetes in Ireland. Retinopathy screening has been standardised in Ireland, these findings provide useful baseline statistics to monitor the impact of this population-based screening programme.

Keywords: Diabetes; Diabetic Retinopathy; Trends; Epidemiology; Adults

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1. INTRODUCTION

Vision impairment is a major public health problem worldwide [1]. In 2010, it was estimated that 0.5% of the global population were blind [1]. In Ireland, the prevalence of blindness increased from 0.2% in 2003 [2] to 0.3% in 2010 [3]. Worldwide approximately 80% of visual impairment cases can be prevented or cured [4]. In order to reduce the global burden of visual impairment, nine preventable causes of visual impairment have been prioritised on the global public health agenda including diabetic retinopathy [4]. Compared to the general population, individuals with diabetes are at an increased risk of losing their eyesight [5]. Genz et al. found that the risk of blindness in an individual was 2.4 times that of an individual without diabetes [6]. In Ireland there is no diabetes register or national data-capture system to observe diabetes trends in diabetes incidence or prevalence over time. However, findings from a recent systematic review [7] suggest that the prevalence of diagnosed diabetes increased from 2.2% in 1998 to 5.2% in 2015. The review was unable to distinguish between the various types of diabetes [7]; however it can be assumed that type 2 diabetes is driving the increase in prevalence as it accounts for 90 % of all diabetes cases [8]. As the prevalence of diabetes rises, visual impairment due to diabetic retinopathy represents a growing global public health challenge [9].

Diabetic retinopathy is a leading cause of preventable vision loss in countries such as the UK [10] and the USA [11]. In Ireland, it was the second most common cause of blindness among adults aged 16-64 years in 2003, with an incidence rate of 0.7 per 100 000 adults [2]. Retinitis pigmentosa was the most common cause of blindness among adults aged 16-64 years in 2003; with an incidence rate of 0.9 per 100 000 adults [2]. The individual and societal costs of visual impairment due to diabetic retinopathy are significant [12, 13], and include increased healthcare costs [14, 15], loss of productivity [15], and sever reduction in healthy life years [16] and quality of life [17].

It is now widely accepted that systematic screening for diabetic retinopathy has the potential to reduce the incidence of sight-threatening visual impairment [18]. A reduction of rates of blindness

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due to diabetic retinopathy have been noted in countries that have established population-based retinal screening programmes as part of their national diabetes strategy [6, 19-23].Up until recently, there was no national population-based screening programme for diabetic retinopathy in Ireland; screening was delivered on a limited basis by local services using different models of service provision [24]. In 2013, a national retinal screening programme (Diabetic RetinaScreen) was introduced in Ireland [25] with the objective of reducing blindness by 40% through the implementation of a standardised screening and treatment service [26]. The service was introduced on a phased basis, patient registration began in 2013 and full implementation was achieved in late 2014.

In 2010, the World Health Organisation highlighted the importance of within-country data on visual impairment to facilitate global efforts aimed at monitoring and eliminating avoidable blindness [4]. Given that the national programme has only been recently introduced, there is limited national data on rates of visual impairment due to diabetic retinopathy in Ireland [7]. Therefore, this study used national blind registry data to establish current rates of visual impairment and blindness due to diabetic retinopathy. Data from blind registers allow the absolute burden of visual impairment attributed to diabetic retinopathy to be quantified [27]. In Ireland, blind registry data have been previously used to describe trends in all-causes of blindness in 1996 [28] and 2003 [2]. The aims of this study were to 1) estimate the incidence of visual impairment and blindness due to diabetic retinopathy among (a) the total adult population and (b) population with diagnosed diabetes in Ireland over a ten year period (2004-2013); 2) explore whether these rates have changed over time and 3) estimate the relative, attributable and population attributable risk of visual impairment and blindness due to diabetic retinopathy in Ireland in 2013.

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2. SUBJECTS MATERIALS AND METHODS

2.1 Data source

Data from the National Council for the Blind of Ireland (NCBI) were analysed. The NCBI is a charitable organisation which provides support and services to people experiencing sight loss [29]. Anyone who is having significant difficulty with their eyesight can be referred to the NCBI by a health care professional or family member; self-referral is also possible [29]. Once referred, the individual's information is added to the NCBI database; however, an ophthalmic assessment report (OAR), to confirm the level of visual impairment, is necessary to officially register with the service [29]. Registration with the NCBI is not compulsory, however those who register can access a range of NCBI support services and registration is also required to qualify for the state-provided Blind Welfare Allowance [30]. The NCBI registry comprises data on approximately 15 causes of visual impairment and blindness, including macular degeneration, glaucoma, cataract, optic atrophy, retinitis pigmentosa and diabetic retinopathy [2, 3]. Information such as service-user demographics (gender and date of birth), date of registration, visual acuity score and cause of visual impairment are recorded on a centralised national database. Information on type of diabetes, the stage of diabetic retinopathy, or risk factors for diabetic retinopathy is not recorded. In this study, anonymised data on visual impairment due to diabetic retinopathy in adults aged 18-69 years, (January 2004-December 2013) were obtained for analysis.

2.2 Numerator data

The number of new cases of visual impairment due to diabetic retinopathy was extracted from the NCBI database for each calendar year. The number of new cases due to all other causes of visual impairment was extracted for 2013. Cases were excluded if visual acuity score was not recorded. In Ireland, visual impairment is categorised into three levels: mild visual impairment (visual acuity

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between 6/12 and 6/18 inclusive), moderate visual impairment (best-corrected acuity of less than 6/18 but better than or equal to 6/60 in the better-seeing eye) and blindness (visual acuity of 6/60 or less in the better eye or a visual field restricted to 20 degrees or less) [31]. These criteria are commonly used in North America, Australia, and most of Europe [31]. For the purpose of this study, individuals who met the national criteria for mild and moderate visual impairment were defined as 'visually impairment' and those who met the criteria for blindness were defined as 'blind'.

2.3 Denominator data

Annual population estimates were obtained from the Central Statistics Office (CSO), Ireland [32]. A census took place in Ireland in 2006 and 2011; data for other study years were CSO inter-censal estimates [32]. A diabetes register does not exist in Ireland, therefore rates for diagnosed diabetes was taken from model estimates; methods have been described in detail previously [7]. In brief, using data from four nationally representative population-based studies , multivariate Poisson regression models were undertaken to impute annual gender and age-specific (18–29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years) rates of diagnosed diabetes. These gender and age-specific rates were applied to 2004–2013 population data so the absolute number of diabetes cases could be obtained. For the purpose of this study, the absolute number of diabetes cases was categorised into two age groups (18-49 years, 50-69 years). The population without diagnosed diabetes was calculated by subtracting the estimated population with diabetes in 2013 from the total population in 2013.

2.4 Incidence calculations

The incidence of visual impairment and blindness due to diabetic retinopathy in the total population and the population with diagnosed diabetes was calculated for each year 2004–2013; using data from the NCBI as the numerator and the census and estimated diabetes population as the denominator for the total population and diagnosed diabetes populations respectively. The

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incidence of visual impairment and blindness due to all other causes in the population without diagnosed diabetes was calculated for 2013; using data from the NCBI as the numerator and the estimated population without diabetes as the denominator. Rates were expressed per 100, 000 population.

2.5 Statistical analysis

Age-standardised rates in the total population and the population at risk (in 10-year age groups) were calculated using the direct standardisation method, based on the age distribution of the last census in Ireland (2011) and the estimated population with diagnosed diabetes in 2011, respectively; 95% confidence intervals (95% CI) were based on the Poisson distribution. Mean incidence figures, with standard deviations (SD) and 95% CI's, were calculated for the decade. The risk of visual impairment increases with age [33]; therefore analysis was stratified by two arbitrary age groups (18-49 years, 50-69 years). Poisson regression models, using extra Poisson variation, were undertaken to explore variations in rates overtime and to examine departures from linearity between 2004 and 2013. Sensitivity analysis, comparing rates in the total population between census year (2006 and 2011) was also carried out. The number of cases served as the dependant variable, year of registration served as the continuous independent variable and population was entered as the exposure variable. If this model indicated significant changes in the IRR over time (p_{change}), the likelihood ratio test was undertaken to assess linearity. A model including year of registration as a categorical variable was compared to the model with year as registration as a continuous variable. Linearity was determined by an insignificant likelihood ratio test (p_{trend}). The IRR with corresponding 95% CI were reported if linearity was established. A two-sided $p<0.05$ was considered statistically significant.

Age-specific relative risks of blindness and visual impairment (diabetes vs. no diabetes) in 2013 were calculated by dividing the rates in the estimated population with diabetes by the rates in the population without diabetes. The attributable risk (AR) [incidence $_{exposed}$ –incidence $_{unexposed}$],

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attributable risk percent (AR %) [AR/ incidence $_{exposed}$ *100], population attributable risk (PAR) [incidence $_{population}$ –incidence $_{unexposed}$] and the population attributable risk percent (PAR %) [PAR/ incidence $_{population}$ * 100] were also calculated. The AR measures the excess risk attributed to diabetes, using the difference between the risk in individuals with diagnosed diabetes (exposed) and that in individuals without diabetes (unexposed). The PAR measures the excess risk between the risk in the total population in the total population and that in individuals without diagnosed diabetes (unexposed). Analysis was carried out in Stata 13.

3. RESULTS

A total of 357 new cases of diabetic retinopathy were registered with the NCBI during the 10 year period; 16 cases (5%) were excluded as an OAR had not been returned to the NCBI, therefore the level of visual impairment could not be determined. The distribution of these cases over the study period is shown in supplementary file 1. Therefore, 341 new cases were available for inclusion in the current analysis. Between 2004 and 2013, a total of 86 cases were newly registered as visually impaired (supplementary file 2); of these 67% were male and the median age was 62 years (IQR 57-66). The highest proportion of new cases of visual impairment also occurred in those aged 50-59 years (50-69 years: 73 vs. 18-49 years: 13). A total of 255 patients were newly registered as blind (supplementary file 3); of these, 58% were male and the median age of registration was 59 years (IQR 51-65). The highest number of new blind cases occurred in those aged 50-69 years (50-69 years: 195 vs. 18-49 years: 60). During 2013, 207 people (87 visually impaired and 120 blind), were newly registered on the NCBI database due to all other causes.

Over the ten year period, the prevalence of diagnosed diabetes increased from 2.1 % (95% CI: 2.0-2.2) in 2004 to 3.6% (95% CI: 3.5-3.7) in 2013; (p_{trend}= <0.001). Table 1 shows the number of new cases for each year, the total adult population, the estimated adult population with diabetes, the standardised incidence of visual impairment and blindness attributed to diabetic retinopathy. Between 2004 and 2013, the mean annual incidence of visual impairment due to diabetic

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retinopathy was 0.3 per 100,000 population (SD: 0.09; 95% CI: 0.2-0.4) and 10.7 per 100,000 population with diagnosed diabetes (SD: 2.9; 95% CI: 8.6-12.7). During the same time period, the mean annual incidence of blindness due to diabetic retinopathy was 0.9 per 100,000 adults (SD: 0.24; 95% CI: 0.7-1.04) and was 33.2 per 100,000 population with diagnosed diabetes (SD: 10.2; 95% CI: 25.9-40.5). Over a decade, the incidence of visual impairment due to diabetic retinopathy increased in both the total population (IRR: 1.08 [95% CI: 1.01-1.16]; p_{trend}=0.93) and the population with diagnosed diabetes (IRR: 1.05 [95% CI: 1.02-1.1]; p_{trend}= 0.79). In contrast, the incidence of blindness due to diabetic retinopathy in the total population did not significantly change during the study period (p_{change}= 0.73). Over the 10 year period, the annual incidence in the population with diabetes did vary between years (p_{change}=0.01); however, there was no evidence of a linear trend (p_{trend} <0.01).

Figure 1b illustrates the age-specific trends of visual impairment between 2004 and 2013. Among adults aged 18-49 years, the incidence remained steady in the total population (2004: 0.05 [95% CI 0.001-0.3] to 2013: 0.04 [95% CI 0.001-0.4] per 100,000; p_{change} = 0.56), whereas among people with diabetes, the incidence ranged from 5.4 (95% CI 0.1-30.0) in 2004 to 2.3 (95% CI 0.05-12.8) per 100,000 in 2013 but did not significantly change overtime (p_{change} = 0.83). In contrast, among adults aged 50-69 years, the incidence increased in both the total population (2004: 0.3 [95% CI 0.08-1.2] to 2013: 1.3 [95% CI 0.6-2.2]; [IRR: 1.09 [1.05-1.13]; p_{trend} = 0.92) and the population with diabetes (2004: 7.6 [95% CI 15.8-22.5] to 2013: 18.1 [95% CI 9.4-31.6]); [IRR: 1.05 [95% CI: 1.02-1.09]; p_{trend} = 0.92).

Figure 1c illustrates age-specific trends of blindness due to diabetic retinopathy between 2004 and 2013. Among adults aged 18-49 years, the incidence remained stable in the total population (2004: 0.2 [95% CI 0.08-0.5] to 2013: 0.2 [95% CI 0.07-0.6] per 100,000; p_{change} = 0.56). However, among people with diabetes, the incidence ranged from 26.9 (95% CI 8.7-62.8) per 100,000 in 2004 to 11.5 (95% CI 3.7-26.8) per 100,000 in 2013 but did not significantly change overtime (p_{change} = 0.45). Among adults aged 50-69 years, the incidence also remained stable in the total population (2004:

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1.7 [95% CI 0.9-2.9] to 2013: 1.2 [95% CI 0.5-2.1] per 100,000; p_{change} = 0.15). Whereas among people with diabetes, the incidence varied from 33.3 (95% CI 17.7-56.9) in 2004 to 16.6 (95% CI 8.3-29.7) per 100, 000 in 2013 (p_{change} = 0.03); however, there was no evidence of a linear trend (p_{trend} <0.01).

Sensitivity analysis: trends in the total population between census years (2006-2011)

The results from the sensitivity analysis demonstrated that the incidence of visual impairment (p_{change}= 0.31) or blindness (p_{change}= 0.59) due to diabetic retinopathy in the total population did not significantly change between 2006 and 2011. Among adults aged 18-49 years, the incidence of visual impairment and blindness remained stable (visual impairment: 2006: 0.05 [95% CI 0.08-0.5] to 2011: 0.09 [95% CI 0.07-0.6] per 100,000; p_{change} = 0.98; blindness: 2006: 0.3 [95% CI 0.08-0.5] to 2011: 0.3 [95% CI 0.07-0.6] per 100,000; p_{change} = 0.37). Among adults aged 50-69 years, the incidence of visual impairment ranged from 0.6 (95% CI 17.7-56.9) in 2006 to 1.0 (95% CI 8.3-29.7) per 100, 000 in 2011 but did not significantly change over time (p_{change} = 0.37). Whereas, the incidence of blindness remained stable (2006: 2.6 [95% CI 0.08-0.5] to 2011: 2.4 [95% CI 0.07-0.6] per 100,000; p_{change} = 0.51).

The relative risk, attributable and population attributable risk of blindness and visual impairment in 2013 are shown in Table 2. In adults aged 18-49 years, the risk of blindness was 5.6 times higher in the population with diabetes compared to those without diabetes. In 2013, 9% of the risk of blindness in the entire population was attributable to diabetes. In adults aged 50-69 years, the risk of visual impairment was 3.9 times higher in the population with diabetes compared to those without diabetes. Sixteen per cent of the risk of visual impairment in the entire population was attributable to diabetes in 2013.

4. DISCUSSION

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To our knowledge, this is the first study to describe national rates of registered blindness and visual due to diabetic retinopathy among the population with diagnosed diabetes in Ireland. We observed a change in the incidence of blindness due to diabetic retinopathy among people with diabetes over the study period, however there was insufficient evidence to confirm a downward trend. This is in accordance with previous research describing national trends in the incidence of lower leg amputations between 2005 and 2009 among the population with diabetes [34]. Findings from the present study are in contrast to international research where a decrease in the incidence of blindness [6, 10, 20, 22, 23, 35-37] and other diabetes related complications [38] have been documented. It has been suggest that while the rates of some diabetes complications have decreased, the absolute number of cases will continue to rise because of the rising prevalence of diabetes [38]. In the present study, we observed an increase in the prevalence of diagnosed diabetes; longer duration of diabetes diagnosis is an established risk factor for diabetic retinopathy [9]. After 20 years of diabetes, nearly all individuals with type 1 diabetes and more than two-thirds of individuals with type 2 diabetes will develop some degree of retinopathy [12]. Therefore it is possible that the full impact of the diabetes epidemic has not yet been realised in Ireland. In contrast, an increase in visual impairment was evident in the total population and among people with diabetes.

Comparison with other countries is limited due to differences in visual impairment criteria, differing age ranges and varying methods used to estimate the population at risk [8]. In the UK, from 2000 to 2009, Hall et al. [20] described a decrease in the incidence of blindness attributable diabetes from 1.43 to 1.10 per 100,000 total population, and 59.7 to 23.9 per 100,000 population with diagnosed diabetes. However, unlike the present study, these rates included adults over 70 years rather than being restricted to adults aged 18-69 years. Elsewhere in the UK, between 2001 and 2005, the mean annual incidence of blindness due to diabetic retinopathy among adults aged 16-64 years with diabetes was 22 per 100,000 population [19]. This estimate is lower than our mean annual estimate

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(22 vs. 33); however the sample in our study was older on average (55 years vs. 59 years) which could lead to a higher rate of blindness [33]. In the USA, The Wisconsin Epidemiologic Study of Diabetic Retinopathy, reported a decline in the incidence of severe visual impairment over a 25 year period among those with type 1 diabetes [39].

Decreasing trends of blindness and visual impairment due to diabetic retinopathy have been attributed to a combination of factors, including improvements in disease management and risk factor control, earlier detection and treatment of diabetic retinopathy through the implementation of standardised retinopathy screening programmes [21, 40]. In Ireland, data on risk factors for diabetic retinopathy are not routinely collated at a population-level, therefore we were unable to quantify trends in mean HbA1c levels or mean blood pressure during the study period. Prior to the introduction of the national diabetic retinal screening programme, there was wide variation in the delivery of diabetic retinopathy screening in Ireland [24]. Regional screening initiatives may have contributed to the changing incidence of visual impairment and blindness observed in the present study. We found that the incidence of visual impairment due to diabetic retinopathy almost doubled over a ten year period; this may be indicative of local efforts to screen for diabetic retinopathy. The initial introduction of a screening programme results in the detection of more diabetic retinopathy cases [21]. Countries that have introduced population-based retinal screening programmes have observed a decline in the frequency [21]and treatment [40] of sight-threatening diabetic retinopathy over time. The national Diabetic RetinaScreen programme was fully implemented in 2014; we hypothesize that initially, the increasing trend in visual impairment due to diabetic retinopathy will continue and will gradually decline post-implementation.

Strengths and limitations

The strengths of our study include the analysis of a national centralised database that has been previously used in Ireland to describe rates of all-causes of blindness in 1996 [28] and 2003 [2]. To

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our knowledge, rates of blindness due to diabetic retinopathy have not been estimated since 2003. Furthermore, the risk of visual impairment attributable to diabetes has not been previously reported within the Irish population.

However, our study has some limitations that must be considered. Firstly, implications of using blind registry data to describe rates in visual impairment and blindness have been discussed elsewhere [2, 20, 41]. It has been suggested that blind registry data may be incomplete, leading to an underestimation the true burden of blindness. For example, data from the UK [42] has demonstrated that partially sighted individuals are less likely to be registered than blind patients. In Ireland, both visually impaired and blind individuals can avail of the services provided by the NCBI [29]. However, selection bias due to an underreporting of visual impairment cases maybe possible as, unlike blindness, registration to the NCBI is not financially incentivised [30]. Referral to the NCBI also may depend on severity of visual impairment further increasing the possibility of self-selection. Therefore, in the present study the annual incidence of visual impairment may be underestimated.

Previous studies have shown that 21-50% [2, 41, 42] of patients are not listed on blind registers; furthermore, partially sighted individuals are less likely to be registered than blind patients [42]. Non-registration has been associated with temporary and treatable causes of blindness [2, 42]; however, blindness due to diabetic retinopathy is irreversible and there is no evidence to suggest that under-registration is more likely in those with diabetes. It is also recognised that blind registry data is only a surrogate measure of incident blindness [20, 42], where changes in rates may reflect reporting differences over time rather than true changes in disease incidence. In the present study, it is possible that the NBCI may have become a better known resource over time thereby impacting registration to the service. For instance, our findings demonstrated a sharp increase in the number of blind cases during 2008, which resulted in a sharp increase in incidence. This increase may be attributable to a national campaign specifically highlighting diabetic retinopathy among the general population, which in turn may have increased recording rates to the NCBI during this year.

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Nevertheless, in the absence of any other national data source, blind registries are useful for monitoring trends in diabetes-related blindness [27].

Secondly, similar to previous research [19, 34, 43], we applied secondary data to model our annual diabetes prevalence estimates. We acknowledge that the accuracy of our calculations is dependent on the reliable estimation of the population with diagnosed diabetes. For instance, an underestimation of diabetes cases in our denominator would result in an increase in our attributable risk calculations. In the absence of a national diabetes register, annual estimates on the prevalence of diabetes are lacking [7]. However, our model estimates are derived from four nationally representative studies and the increasing prevalence of diagnosed diabetes among the adult population in Ireland is in accordance with other countries [7]. Therefore the diabetes prevalence estimates used in the present study are the best available in Ireland. Additionally, in accordance with previous research [6, 20, 23, 43], our denominator data does not include those with undiagnosed diabetes; we acknowledge that this would result in an overestimation of rates. Finally, we could not stratify our analysis by diabetes type and duration of disease was unknown. Our rates in the youngest age group serve as a proxy for those with type 1 diabetes, although the small number of cases in the youngest age group could introduce imprecision into our estimates.

Despite these limitations our research provides contemporary data on the trends of diabetes related complications among adults aged between 18 and 69 years in Ireland [7]. Diabetic retinopathy is potentially preventable by adequate risk factor control [12]. Additionally, early detection and timely treatment can prevent the onset of sight threatening visual impairment [12, 18] . Our risk calculations indicate that in 2013, prevention or early detection of diabetic retinopathy may have resulted in 82% fewer new cases of blindness in adults aged 18-49 years and 48% fewer new cases of blindness in adults aged 50-69 years. Although causality cannot be inferred in the present study, our findings highlight the need to focus on preventive measures for microvascular complications among

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people with diabetes in Ireland. Evidence suggests that younger adults [44-46] and those with type 1 diabetes mellitus [44-46] are less likely to attend regular retinal screening examinations; non-attendance is a risk factor for poor visual outcomes [21]. Therefore, further research is required to explore patterns of retinal screening attendance among these groups in Ireland. It is essential to develop an understanding of the factors which influence the uptake of the national diabetic retinal screening programme in order for this new investment to be effective [47]. Findings from this research will provide useful baseline statistics to monitor the future impact of the national diabetic retinal screening programme [25].

Authors' contribution

MLT, PMK conceived and designed the study. MLT researched data. MLT analysed the data. MLT wrote the manuscript. PMK, SMMc, CMB, APF, RJC reviewed the manuscript. MLT edited the manuscript. MLT, PMK, SMMc, CMB, APF, RJC approved final manuscript.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Acknowledgements

The authors would like to thank the National Council of the Blind Ireland for the use of data and Dr Mark James (Community Ophthalmologist, Cork University Hospital) for assisting with interpretation of visual acuity scores. Marsha Tracey and Patricia Kearney are funded by the Health Research Board Leadership Award in Diabetes (RL/2013/7). Dr Sheena Mc Hugh is funded by the Centre for Ageing and Development Research in Ireland (CARDI) Leadership Fellowship.

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Table 1 New registrations resulting from diabetic retinopathy, estimated population data and the standardised incidence of visual impairment and blindness, Ireland 2004-2013.

Year	Adult population		Number of new cases due to diabetic retinopathy		Incidence of visual impairment due to diabetic retinopathy (per 100,000 pop [95 % CI])		Incidence of blindness due to diabetic retinopathy (per 100,000 pop [95 % CI])	
	Total	Diagnosed diabetes	Visual impairment	Blindness	Total	Diagnosed diabetes	Total	Diagnosed diabetes
2004	2712428	57628	4	18	0.16 (0.05-0.3)	6.4 (2.4-13.9)	0.68 (0.4-1.0)	31.9 (21.6-45.7)
2005	2789808	61881	6	19	0.23 (0.09-0.4)	9.6 (4.4-18.2)	0.72 (0.5-1.0)	29.9 (19.8-43.2)
2006	2879284	65829	6	28	0.23 (0.09-0.4)	8.9 (3.9-17.6)	1.01 (0.6-1.4)	42.7 (30.5-58.1)
2007	2990318	71893	8	25	0.26 (0.1-0.5)	11.7 (5.7-20.9)	0.87 (0.5-1.3)	35.2 (24.2-49.4)
2008	3061169	77777	9	42	0.29 (0.1-0.5)	10.6 (5.1-19.6)	1.43 (1.0-1.9)	54.4 (40.5-71.5)
2009	3077885	83627	5	26	0.16 (0.5-0.4)	6.4 (2.3-13.9)	0.87 (0.5-1.3)	33.1 (22.5-46.9)
2010	3075576	89651	13	27	0.42 (0.2-0.7)	15.9 (8.9-26.4)	0.87 (0.6-1.3)	31.9 (21.6-45.7)
2011	3077810	96470	11	29	0.35 (0.2-0.6)	12.3 (6.1-22.0)	0.94 (0.6-1.4)	30.9 (20.7-44.4)
2012	3052159	102775	12	25	0.39 (0.2-0.7)	13.4 (6.9-23.4)	0.81(0.5-1.2)	26.7 (17.3-39.4)
2013	3032956	109842	13	16	0.39 (0.2-0.7)	11.7 (5.7-21.0)	0.52 (0.3-0.8)	14.9 (8.2-25.1)

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Table 2 Relative, attributable and population attributable risk of visual impairment and blindness due to diabetic retinopathy in Ireland, 2013.

	VI	Blindness
Relative risk (95% CI)		
No diabetes	1	1
18-49 years	1.7 (0.2-12.3)	5.5 (2.2-13.6)
50-69 years	3.9 (2.0-7.4)	1.9 (1.1-3.6)
AR /100,000 diabetes pop		
18-49 years	1.0 (-0.03-7.4)	9.4 (0.7-19.4)
50-69 years	13.4 (3.1-23.7)	7.8 (2.2-17.8)
AR % in diabetes pop		
18-49 years	44.6 (-3.9-94.5)	81.6 (53.7-92.7)
50-69 years	74.2 (51.0-86.4)	47.7 (8.4-71.9)
PAR /100,000 pop		
18-49 years	0.02 (-2.2-7.3)	0.3 (0.01-10.3)
50-69 years	0.9 (0.04-15.2)	0.5 (1.5-13.7)
PAR % in total pop		
18-49 years	1.7 (-4.7-18.7)	8.5 (0.3-17.9)
50-69 years	16.8 (4.5-28.7)	5.9 (1.8-13.1)

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Figure 1 Age specific trends in the incidence of A) Any visual impairment; B) Mild and moderate visual impairment and C) Blindness due to diabetic retinopathy among the total adult population and adults with diagnosed diabetes, Ireland 2004-2013.

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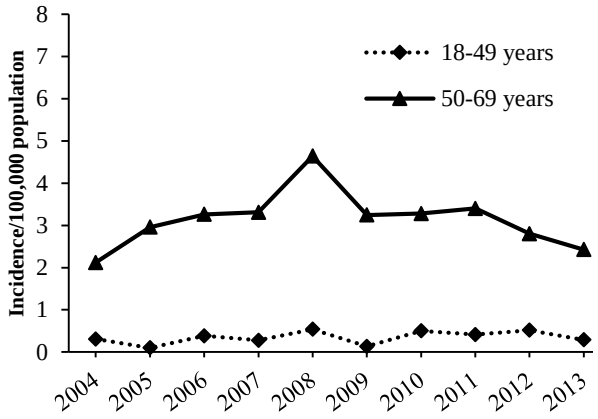
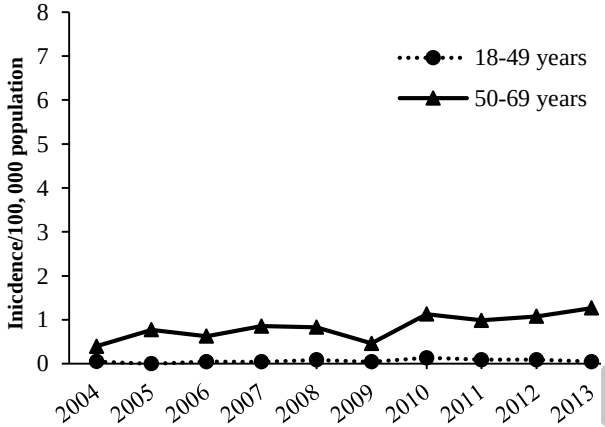
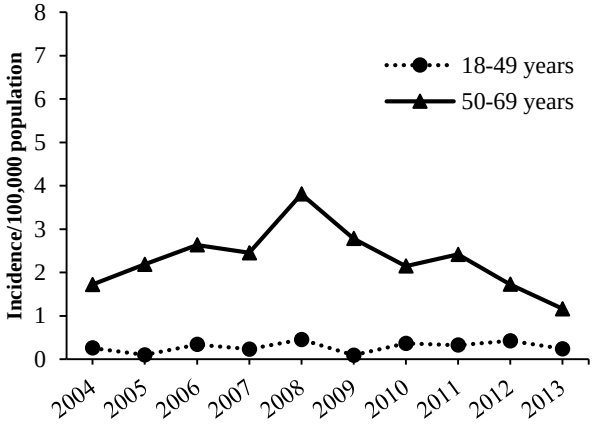
A) Any visual impairment
Total population



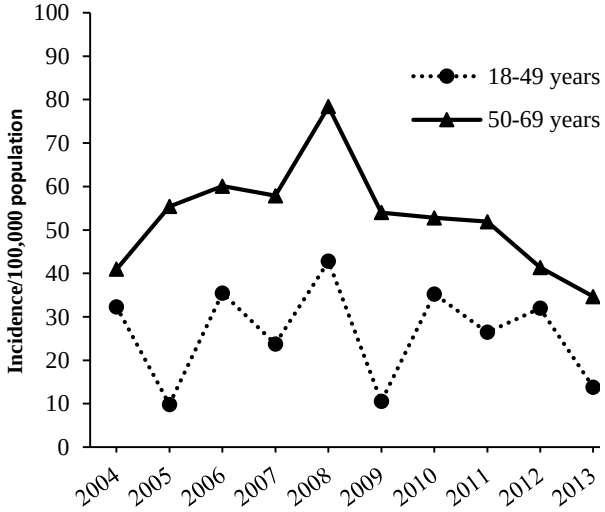
B) Mild and moderate visual impairment
Total population



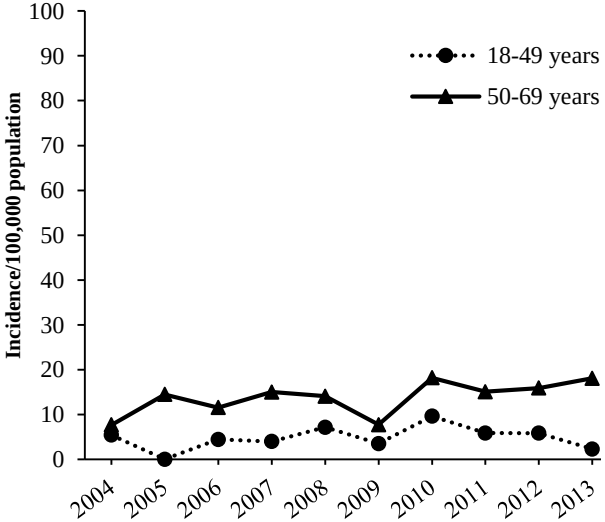
C) Blindness
Total population



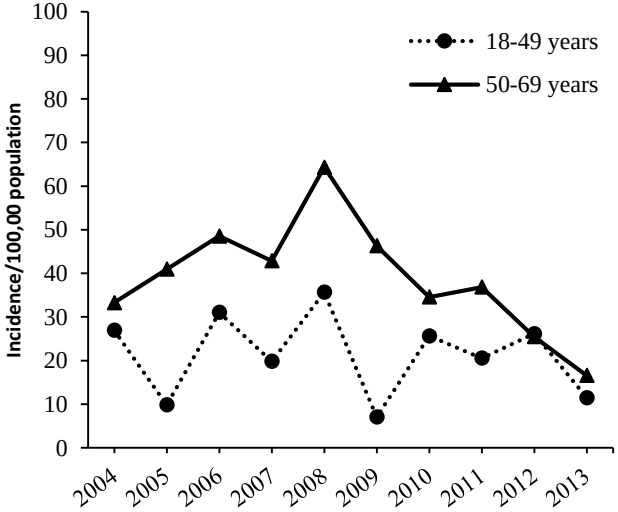
Population with diagnosed diabetes



Population with diagnosed diabetes



Population with diagnosed diabetes



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Highlights

- This is the first study to describe trends in the incidence of visual impairment and blindness due to diabetic retinopathy among adults aged 18-69 year in Ireland.
- Over a decade, the incidence of visual impairment has increased whereas there was no evidence of a linear trend in the incidence of blindness.
- A national retinal screening programme was fully implemented in 2014. These findings provide reliable national data to monitor the impact of this population-based screening programme.

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