An effective programme to systematic diabetic retinopathy screening in order to reduce diabetic retinopathy blindness

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Abstract

The number of people identified with diabetes in England increased by nearly 5% during 2011-2012 to well over 2.5 million. During 2011-2012 the NHS Diabetic Eye Screening Programme screened more than 1.9 million people. In general, the UK is doing very well with its DR screening targets. It is a world leader in diabetic retinopathy screening, having offered 85.7% of eligible diabetic patients the screening programme. However, the target is 100% and efforts are still being made to improve screening locally. Our aim is to evaluate the prevalence of sight-threatening diabetic retinopathy (STDR) (proliferative retinopathy or maculopathy), the number of patients needing laser treatment or vitrectomy and registered blind in the last 12 months in a defined population. We did a twelve-month retrospective database review at the Systematic Diabetic Retinopathy Screening Service at Wirral University Hospital Trust, United Kingdom. The effectiveness of different screening modalities has been widely investigated. UK studies show sensitivity levels for the detection of sight-threatening diabetic retinopathy of 41%-67% for general practitioners, 48%-82% for optometrists, 65% for ophthalmologists, and 27%-67% for diabetologists and hospital physicians using direct ophthalmoscopy. Sensitivity for the detection of referable retinopathy by optometrists have been found to be 77%-100%, with specificity of 94%-100%. Photographic methods currently use digital images with subsequent grading by trained individuals. Sensitivity for the detection of sight-threatening diabetic retinopathy have been found 87%-100% for a variety of trained personnel reading mydriatic 45° retinal photographs, with specificities of 83%-96%. The British Diabetic Association (Diabetes UK) has established standard values for any diabetic retinopathy screening programme of at least 80% sensitivity and 95% specificity. We used descriptive analyses to characterise the study population and patterns of diabetic retinopathy, and used *t* tests and χ^2 tests to explore differences between patients without any retinopathy and those who developed any, background, or referable retinopathy. Parametric survival analysis with covariates identified those factors associated with the development of referable retinopathy. The presence of diabetic retinopathy was determined after each screening event during the study period. Although intended to occur annually, screening took place at variable times during the one year period. Of known diabetics in a total population 325.000, 84% accessed screening and 15.196 (4.7%) were screened. 748 were referred with referable retinopathy. 16% of the patients needed laser treatment for the first time, 30 patients needed vitrectomy, and 16 were registered blind. To evaluate the effectiveness of diabetic retinopathy screening (DRS) service we did a retrospective comparative analysis of 2 year DRS data in Wirral (2010-2012). An increase of 6.8% in the number of diabetics was noted over the last 12 months compared to the previous period. Referable retinopathy decreased from 5.6% for 2010-2011 to 4.94% during the same period in 2011-2012. In particular, the incidence of proliferative retinopathy (R3) has dropped from 0.7% last year to 0.52% this year. STDR has significant impact on ophthalmic services, but a well-implemented program provides timely treatment, reducing the need for vitrectomy and blind registration and serving as a benchmark to plan service delivery in a similar population.

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Introduction

Visual impairment adds to the burden of several other microvascular and macrovascular complications in people with diabetes, threatens independence and compromises quality of life [1]. Estimates of blindness in diabetes from the United Kingdom (UK) are mainly based on audits of certifications of visual impairments which are not population-based estimates [2-9]. Other sources of data on diabetes-related visual impairment in the UK are derived from multipurpose health surveys aimed at a specific population [10-12] or limited to the Caucasian population [13-17].

The demographic composition of the UK is changing with a rise in the ageing population and most of its metropolitan cities now have an ethnically diverse composition. The prevalence of diabetes is disproportionately higher in the non-Caucasian ethnic groups [18]. It is clear that better glycaemic and blood pressure control among people with diabetes has resulted in a reduction of adverse outcomes of diabetes as observed in previous studies conducted in the United States and the UK [19, 20]. A recent report from the UK also suggested that diabetic retinopathy (DR) is no longer the most common cause of visual impairment in the working age-group [2]. It is important to obtain current population-based data on low vision and severe visual impairment to understand the impact of these changes on the healthcare burden in the UK. These contemporary data will also provide baseline data to assess the impact of diabetic retinopathy screening and

forth-coming new treatment options for diabetic macular edema.

In 2010, the Association of Public Health Observatories (AHPO) prevalence model estimated that there were approximately 3 million people aged 16 years or above with undiagnosed and diagnosed diabetes in England [21]. The Quality and Outcomes Framework (QOF) requires each general practice to maintain a register for all people aged 17 years and over with diabetes mellitus, which specifies whether the person has Type 1 or Type 2 diabetes. These data are uploaded to the diabetic register maintained by the DR screening programme. The UK has one of the most developed and quality assured DR screening programmes in the world with a population coverage ranging from 80%-95% [22]. People with sight threatening disease are referred to hospital retinal services for timely management. It is therefore feasible to obtain current epidemiological data from a large nationally representative cohort on visual impairment in people with diagnosed diabetes.

Diabetic retinopathy (DR) is the most common complication of diabetes mellitus and is currently the leading cause of blindness in the economically active population in developed countries [23]. The initially latent disease could lead to vision loss without any symptoms initially. Timely diagnosis and therapy however can significantly decelerate its progress, necessitating regular DR screening or appropriate follow-up in all patients with diabetes. Screening can be carried out by direct and indirect ophthalmology or increasingly by using photographic methods [24].

The effectiveness of different screening modalities has been widely investigated. UK studies show sensitivity levels for the detection of sight-threatening diabetic retinopathy of 41%-67% for general practitioners, 48%-82% for optometrists, 65% for ophthalmologists, and 27%-67% for diabetologists and hospital physicians using direct ophthalmosc [25, 26]. Sensitivity for the detection of referable retinopathy by optometrists have been found to be 77%-100%, with specificity of 94%-100% [27].

Photographic methods currently use digital images with subsequent grading by trained individuals. Sensitivity for the detection of sight-threatening diabetic retinopathy have been found 87%-100% for a variety of trained personnel reading mydriatic 45° retinal photographs, with specificities of 83%-96% [28]. The British Diabetic Association (Diabetes UK) has established standard values for any diabetic retinopathy screening programme of at least 80% sensitivity and 95% specificity [29, 30].

Regular DR screening is centralized in several developed countries due to cost-efficiency and quality control issues [31]. Digital fundus images are captured at the place of patient care and forwarded to a grading center for evaluation by specially trained human graders or ophthalmologists [32]. The system operates with high accuracy but due to its labor intensive nature, it might be poorly scalable in economically challenged countries [33].

In order to improve scalability and cost-effectiveness, many research groups are working on developing automated image analysis technologies [34]. Introducing these technologies in DR screening could substitute first phase examinations performed by human graders. Following automated pre-screening, human graders would only have to examine images that are either questionable or true positive, and potentially carry out quality control on a subset of those deemed normal by the software [35]. Preliminary results are promising, sensitivity and specificity indicators of automated systems are close to that of human graders [36-38]. An international Retinopathy Online Challenge is available in order to compare the results of image processing based algorithms for DR identification via mycroaneurism detection. The system developed by our team currently performs the best on this challenge [39].

The NHS Diabetic Eye Screening Programme (NDESP) is responsible for ensuring that routine screening for diabetic retinopathy is offered to all people with diabetes aged 12 and over in England. (More information about the programme can be found at diabeticeye.screening.nhs.uk.).

Diabetic eye screening is offered to all people with diabetes (type 1 and 2) aged 12 and over every year. Screening is freely available on the NHS and is delivered by more than 80 local programmes in many locations, including GP surgeries, hospitals and optician practices.People identified as having diabetes are referred to the screening programme by their GP. Annual screening is important as early detection and effective treatment of diabetic retinopathy can prevent sight loss.

Subjects, material-methods

Data collection

The majority (>95%) of the population in the UK are registered with a family practice. Since the introduction of the Quality and Outcomes Framework (QoF) all people diagnosed with diabetes are placed on a register with their local family practices so that systematic care can be provided. Data on age, gender and type of diabetes and ethnicity are uploaded from practice diabetes registers into a single collated list at the local DR screening programmes. The digital photographic diabetic retinopathy screening programmes in the UK are well-established and 100% of people with diabetes are offered screening and the uptake rates are at least 70%, with most screening programmes achieving over 85% annually. It is therefore possible to analyse population-based data on visual acuity on all people diagnosed with diabetes who take up these services.

Visual acuity testing

The protocols for recording visual acuity in both screening programmes were as recommended by the National Screening Committee [40]. Presenting visual acuity for distance was recorded for each eye before dilating the pupils for fundus photography. This was measured with the participant wearing their “walk-in” optical correction (i.e. spectacles or contact lenses) using Early Treatment of Diabetic Retinopathy Study (ETDRS) charts. If no letters were read at 2 metres, visual acuity was assessed as counting fingers, hand movements, perception of light, or no perception of light. The visual acuity of the better eye was used for all analyses. Age-standardisation of the prevalence of visual impairment in the minority

ethnic groups was done based on the age-structure of the white population.

Screening and grading of diabetic retinopathy

A mydriatic 2-field digital photography, one centred on the optic disc and the other on the macula was carried out on all diabetic people attending for screening. Trained graders carried out a full disease grade on all image sets; a different grader then independently assessed 10% of the no-disease sets and all-disease image sets. If there was a difference of opinion about referral, the images were arbitrated by an ophthalmologist. The grading of DR was done according to the English Retinopathy Minimum grading classification [41]. As some people with diabetes were followed up in secondary care, the data on the grades of DR for these people were obtained from hospital records.

Trained staff use a standardised protocol to grade diabetic retinopathy, which is an enriched version of the English National Screening Protocol, and take the worst grade for either eye as the final grading level. We used the following grading categories of retinopathy: none present, background, preproliferative or proliferative, and maculopathy (based on surrogate markers such as exudates within 1 disc diameter of the fovea).

For the statistical analysis, we defined referable retinopathy as participants with preproliferative or proliferative retinopathy (with or without maculopathy), or maculopathy with background retinopathy. This category relates to those who would, according to guidelines, need referral to the hospital eye service for further assessment or treatment. Digital retinal images were not considered gradable if the retina of both eyes could not be visualised adequately–that is, retinal vessels were not visible within 1 disc diameter of the centre of the fovea and fine vessels were not visible across the surface of the optic disc.

Statistical analysis

We used descriptive analyses to characterise the study population and patterns of diabetic retinopathy, and used *t* tests and χ^2 tests to explore differences between patients without any retinopathy and those who developed any, background, or referable retinopathy. Parametric survival analysis with covariates identified those factors associated with the development of referable retinopathy.

The presence of diabetic retinopathy was determined after each screening event during the study period. Although intended to occur annually, screening took place at variable times during the one year period.

Results

Of known diabetics in a total population 325.000, 84% accessed screening and 15.196 (4.7%) were screened. 748 were referred with referable retinopathy. 16% of the patients needed laser treatment for the first time, 30 patients needed vitrectomy, and 16 were registered blind.

To evaluate the effectiveness of diabetic retinopathy screening (DRS) service we did a retrospective comparative analysis of 2 year DRS data in Wirral (2010-2012). An increase of 6.8% in the number of diabetics was noted over the last 12 months compared to the previous period. Referable retinopathy decreased from 5.6% for 2010-2011 to 4.94% during the same period in 2011-2012. In particular, the incidence of proliferative retinopathy (R3) has dropped from 0.7% last year to 0.52% this year.

Discussion

The prevalence of type 2 diabetes mellitus (T2DM) has been increasing, owing to increases in overweight and obesity, and decreasing levels of physical activity, as well as the changing demographic structure of the population. The York and Humber Public Health Observatory estimates that about 40% of the increase in England is due to changes in age and ethnic group structure, and 60% to lifestyles, especially obesity.

People can develop T2DM without symptoms. Some have symptoms without recognising them as being related to diabetes. Up to 20% of people with T2DM may be undiagnosed. They may have diabetic complications such as eye disease (diabetic retinopathy) by the time they are diagnosed, or may suffer a heart attack, without any warning. Undiagnosed diabetes can be detected by screening for elevated blood glucose levels.

Diabetic retinopathy (DR) is the fifth-leading cause of global blindness. Diabetic retinopathy affects 1.8 billion people, and represents 4.8% of the world's blindness and is the most common cause of blindness among people of working age in the developed world [42, 43]. Waiting for the diabetic to present with visual problems is not a good strategy. By this time, the condition may have advanced and visual loss may be irreversible. Thus, in order to catch DR early, screening is mandatory.

Younis et al [44-46] showed prevalence of all grades of retinopathy, incidence and progression of sight threatening retinopathy (STDR) in type 1 and type 2 diabetics entering a systematic primary care-based eye screening programme.

Studies of epidemiology [47-49] have shown incidence and changes in visual impairment prevalence as well as vision related quality of life in type 1 diabetics.

The cost of screening and effective treatment of sight threatening DR are balanced economically in relation to total expenditure on health care including the consequences of leaving the disease untreated [50-52].

Diabetes complications are estimated to cost the NHS around £1 million an hour and can have a devastating effect on people's quality of life. It is vital that all of the 2.6 million people with diabetes are armed with the knowledge and confidence to manage their diabetes effectively. 34% are at risk of serious health problems such as blindness, heart disease, amputation and kidney failure. (http://www.diabetes.org.uk. Nov 2009)

The importance of educating individuals regarding the need for screening has been highlighted in the National Institute for Health and Clinical Excellence (NICE) diabetes guidelines document, so that attendance is not reduced by ignorance of need or fear of outcome.

Strengths and weaknesses of the study

The large sample size was one of the main strengths of this study. Furthermore, all participants were screened for the presence of retinopathy by a standardised protocol of digital retinal imaging and subsequent grading by trained staff. However, screening was restricted to two 45° retinal images per eye, and only limited information was available on putative risk factors for the development of diabetic retinopathy (we could not obtain measures of glycaemic control, blood pressure, and lipid concentrations).

Future research

Our future research will explore the implications of varying the screening interval using risk stratification. To better predict the development of retinopathy, further research should investigate additional risk factors (for example, the individual and collective effects of glycaemic control (HbA_{1c}), blood pressure, albumin excretion, and lipid status, as well as possible treatments). These findings could improve risk stratification by better defining safe screening intervals on an individual basis. Another important area to investigate further includes the economic effect of the different screening intervals.

In conclusion, systematic Diabetic retinopathy screening in Wirral has helped ensure that people with diabetes have the opportunity to have their eyes examined regularly and identify treatable retinopathy. The model of using hospital based services and community optometrists helps ensure that access is not a problem. An organised review of the patients following screening within our hospital eye service has helped plan delivery of care, bench mark the service and thereby reduce overall blindness due to his condition. About 85% of our diabetics have accessed the service and we hope to ensure 100% uptake at the earliest. Hence we feel that Systematic diabetic retinopathy screening is worth while for the patient, community and health economy. STDR has significant impact on ophthalmic services, but a well-implemented program provides timely treatment, reducing the need for vitrectomy and blind registration and serving as a benchmark to plan service delivery in a similar population.

Ethics statement

The study adhered to the Declaration of Helsinki and was approved by the Chair of the Research Ethics Committee of Wirral Teaching University Hospital NHS foundation trust and the London School of Hygiene and Tropical Medicine. Written consent from patients was not required for this project as only anonymized data from the regional diabetes registers were analysed.

The authors declare that they have no conflicts of interest

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