

Review of Diabetic Retinopathy Screening Methods and Programmes Adopted in Different Parts of the World

Janusz Pieczynski,^{1,2} and Andrzej Grzybowski^{1,3}

1. Chair of Ophthalmology, University of Warmia and Mazury, Olsztyn, Warszawska, Poland;

2. The Voivodal Specialistic Hospital, Olsztyn, Zolnierska, Poland; 3. Department of Ophthalmology, Poznan City Hospital, Poznan, Poland

Abstract

Introduction: One of most common diabetic complications is diabetic retinopathy (DR). Sight-threatening DR can be avoided when diagnosed early and treated in a timely fashion. The aim of this study is to review current worldwide DR screening programmes and studies.

Methods: A PubMed platform search was performed to find clinical trials or studies of current DR screening methods. **Results:** Direct and indirect ophthalmoscopy is still used, but digital photography of the retina seems to be the most efficient, objective and cost-effective.

Conclusions: DR screening programmes are developed all over the world. They help to detect early sight-threatening DR, treat it in a timely fashion and in this fashion help to avoid expensive, advanced treatment or even prevent to develop blindness among working age people.

Keywords

Diabetic retinopathy, screening methods, telemedicine

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Correspondence: Janusz Pieczynski, Voivodal Specialistic Hospital, Zolnierska 18, 10-560 Olsztyn, Poland. E: janusz.pieczynski@op.pl

Diabetes mellitus (DM) is a growing socio-medical problem because of its increasing prevalence and diabetic complication rate. This is also the reason for the large amount of money spent on diabetes treatment and on diabetic complications despite continually improving diabetes care.^{1,2} The International Diabetes Federation's latest study has shown the number of people with diabetes rise from 382 million worldwide in 2013 to 592 million in 2035.³

One of most common microvascular diabetic complications is diabetic retinopathy (DR). It is a most common reason for blindness in developed countries. Sight-threatening DR can be avoided when identified early and cured in a timely fashion.⁴⁻⁷ This is the reason for diabetic screening implementation.

Rules of screening in medicine were established by Wilson and Jungner in 1968 and accepted by the World Health Organization (WHO).⁸ The basic principles for disease screening were as following:

- The condition sought should be an important health problem.
- There should be an accepted treatment for patients with recognised disease.
- Facilities for diagnosis and treatment should be available.
- There should be a recognisable latent or early symptomatic stage.
- There should be a suitable test or examination.
- The test should be acceptable to the population.
- The natural history of the condition, including development from latent to declared disease, should be adequately understood.

- There should be an agreed policy on whom to treat as patients.
- The cost of case finding (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as a whole.
- Case finding should be a continuing process and not a 'once and for all' project.

These rules could be adapted for DR screening. The first attempts were made in 1989, when the St Vincent Declaration was made. According to this declaration, reduction of blindness due to DR by one-third in the following 5 years was planned.⁹ The next attempts on DR blindness reduction were established in 2005 in the Liverpool Declaration.¹⁰ The consensus was to reduce blindness due to DR by 2010, by DR systematic screening covering at least 80 % of the people with diabetes population with the use of trained personnel and access to the proper therapy.

Aim of Study

The aim of this study is to review current worldwide DR screening programmes and studies performed by technicians or primary care physicians (not ophthalmologists), quickly and simply.

Methods

This is a review study. A PubMed platform search was performed, using the following keywords: diabetic retinopathy screening programme, telemedicine and DR, prevented diabetic vision lost to find clinical trials or review studies of current DR screening programmes. We found

57 articles of which finally we analysed 45. English language was preferred, at least for abstracts.

Results

UK

The UK comprises England, Wales, Scotland and Northern Ireland. Each of them started to screen DR and developed their own national DR screening programmes. These services are based on digital colour eye fundus photography and vary in details.¹¹⁻¹⁵

England

A national programme for retinopathy screening in England (English National Screening Programme for Diabetic Retinopathy [ENSPDR]) started in 2006 and in 2012 was relaunched as the NHS Diabetic Eye Screening Programme (NDESP). This service is designed to reduce loss of sight among people with diabetes by early detection and correct treatment of a sight-threatening DR. The programme covers all patients with diabetes 12 years old or over with light perception or more in at least one eye. Screening is performed annually. There are static and mobile screening locations with digital fundus cameras. The protocol consists of two-field colour eye fundus photographs: one in macula centre; one in optic disc centre, taken after pupil dilatation. Retinal photographs are read in a few centralised grading centres.^{11,12,16}

Wales

The Diabetic Retinopathy Screening Service for Wales (DRSSW) was started in 2002 to detect any kind of DR, especially sight-threatening DR.^{17,18} The DRSSW is a mobile screening service with the following protocol of screening: visual acuity, two-field 45° digital photographs (one in macula centre; one nasal) after 1 % tropicamid mydriasis and graded by retinal professionals. Patients with diabetes aged 12 or more and not involved in other screening programmes are covered by this service. Patients with sight-threatening DR are referred to a hospital retinal service. Patients with mild states of DR are advised to improve metabolic control of diabetes. This programme consists of 30 photographic teams and 220 locations in Wales and uses Canon DGi digital cameras. Photographs are graded according to the DRSSW protocol based on the National Screening Committee¹⁹ and the European screening handbook.²⁰ Rate of patient cover is 80 %.¹⁴

Scotland

The Scottish National Diabetic Retinopathy Screening (DRS) service launched in 2006.²¹ Patients with diabetes 12 years and over are automatically identified according to the database of the Scottish Care Information-Diabetes Collaboration and due to this system patient coverage is above 99 %. Screening examination is based on a single, central 45° photograph with mydriasis if required. In case of complications with photographs, slit-lamp is performed. The grading system is centralised.²² Tests with good results with software for automated quality assessment and microaneurysm/dot haemorrhage have been carried out.^{13,23}

Northern Ireland

The Northern Ireland Diabetic Retinopathy Screening Programme (NIDRSP) started in 2002. Its methodology is similar to the DRSSW. It is based on digital eye fundus colour photography with selective pupil mydriasis in patients under 50 years of age. This programme covers all patients with diabetes 12 years of age or over, with patient identification sent to the programme by the GP. Trained readers grade photographs.¹⁵

US

Cuadros et al. presented a study on the EyePACS (picture archive and communication system) programme developed in California.²⁴ They used a licence-free system of taking pictures of the retina and sending them to a grading centre to assess retinopathy status. Pictures were taken by any kind of fundus cameras, but the non-mydratiac type was preferred, for instance, Canon CR-DGi or Canon CR-1. Certified EyePACS photographers took one picture of the external surface of the eye and three pictures of the retina, as follows: optic disc and macula, picture centred on optic disc and picture of the macula and temporal part of the retina. Retinopathy grading system reviewers performed grading of retinopathy. This programme was in operation in California in 2005 to 2006 and expanded to elsewhere in 2008.

We also found research on telemedicine reading of digital photographs of eye fundus of patients with diabetes.²⁵ Patients 18 years of age or over with DM type 1 or 2 were screened. Trained photographers took three photos of the fundus of each eye: one anterior segment and two of retina located nasally and temporally and subsequently read by trained readers using telemedicine. They graded photos according to the British National Health Service's DR grading classification system.²⁶

The American Diabetes Association suggests that seven-field stereo 30° is superior to non-mydratiac digital photography and the second method should only be used for situations where mydriasis does not allow it.²⁷

Analysis of the cost-effectiveness of screening DR in low socio-economic status areas has also been performed.²⁸ This research was carried out for 17 months with the use of digital photography of the retina and grading by a telemedicine centre. There are no data on the exact condition of patients' eye examinations.

Mansberger et al.²⁹ performed a study on checking the usefulness of long-term telemedicine DR screening compared with traditional eye examination. They screened patients with DM 18 years of age or older. One study group was examined traditionally and the second with the use of a non-mydratiac camera and six 45° photographs: stereo on macula and optic disc; non-stereo on peripheries. The researchers concluded that telemedicine increased the percentage of eye examinations and could be a useful method for DR screening.

France

The first telemedical screening for DR started in 2002 in the Paris region and was conducted by Massin et al.^{30,31} They used a non-mydratiac fundus camera by Topcon and performed five-colour photographs of 45° of the central (macula and optic disc) and peripheral retina without pupil dilatation taken by orthoptists. The photographs were compressed and sent via the Internet to the grading centre, where quality of pictures and DR status was assessed. They used Topcon software for that process. The study was active for 18 months.

The Ophthalmology Diabetes Telemedicine Network (Ophdiat), a programme for DR screening, (created 2004; covering the Paris region).³² They used non-mydratiac fundus cameras (Canon or Topcon) and took 45° two-fields colour photos of the retina (one centred in the macula; the second centred in the optic disc). The pictures were taken by orthoptists or nurses and compressed to JPEG format and sent via the Internet to the grading centre, where DR status was assessed. Patients with moderate or more advanced stages of DR, or with unclear pictures, were referred to an ophthalmologist. All other people were screened once a year.

Table 1: Diabetic Retinopathy Screening Studies – Europe

| Authors | Country | Type of Study | Screening Method | Instant Grading/ Telemedicine | Covered Population | Population |
|--|------------------|---|---|---|---|------------------|
| NHS Diabetic Eye Screening Programme | England, UK | National programme | Digital fundus cameras/two-field 45° colour fundus photos/mobile/static camera/pupil dilatation | Telemedicine | Diabetics over 12 years old | Nationwide |
| Diabetic Retinopathy Screening Service for Wales | Wales, UK | National programme | Digital fundus cameras/two-field 45° colour fundus photos/mobile camera/pupil dilatation | Direct grading from fundus camera | Diabetics over 12 years old | Nationwide |
| Scottish National Diabetic Retinopathy Screening Service | Scotland, UK | National programme | Digital fundus cameras/one-field 45° colour fundus photos/mobile camera/pupil dilatation if needed | Telemedicine | Diabetics over 12 years old | Nationwide |
| Northern Ireland DR Screening Programme | Northern Ireland | National programme | Digital fundus cameras/two-field 45° colour fundus photos/mobile camera/pupil dilatation | Telemedicine | Diabetics over 12 years old, under 50 years old | Nationwide |
| Massin et al., 2004 ³⁰ | France | 18-month study | Digital fundus cameras/five-field 45° colour fundus photos/stationary camera/pupil dilatation if needed | Telemedicine | Patients who had no DR previews | Local |
| Ophthalmology Diabetes Telemedicine Network (Ophdiat) Schulze-Döbold, 2012 ³² | France | Programme in region of Paris | Digital fundus cameras/two-field 45° colour fundus photos/stationary camera/pupil dilatation | Telemedicine | Patients had either mild or no DR | Local |
| Deb-Joardar et al., 2007 ³³ | France | Cross sectional study/1-year study | Digital fundus cameras/three-field 45° colour fundus photos/stationary camera/pupil dilatation | Telemedicine | All adult patients | Local |
| Creuzot-Garcher et al., 2010 ³⁴ | France | Regional programme | Digital fundus cameras/three-field 45° colour fundus photos/mobile camera/pupil dilatation | Telemedicine from USB drive | No data | Local |
| Andonegui et al., 2012 ³⁵ | Spain | 24-month study | Digital fundus cameras/five-field 45° colour fundus photos/stationary camera | Instant reading by GPs/possibly referral | Diabetic patients under care of GPs | Local |
| Gibelalde et al., 2010 ³⁶ | Spain | Prospective study | Digital fundus cameras/one-field 45° colour fundus photos/stationary camera | Telemedicine | No previews DR | Local |
| Vleming et al., 2009 ³⁷ | Spain | Prospective, observational study | Digital fundus cameras/four-field 45° colour fundus photos/stationary camera | Telemedicine | All patients sent by GPs and endocrinologist | Local |
| Gomez-Ulla et al., 2002 ³⁸ | Spain | 3-month study | Digital fundus cameras/four-field 45° colour fundus photos/stationary camera | Telemedicine | Patients of the endocrinology unit | Local |
| Lemmetty et al., 2009 ⁴³ | Finland | Regional programme | Digital fundus cameras/colour fundus photos/mobile camera | First grading made by photographer (trained nurse); referral possible if needed | Patient with type 2 DM | Local |
| Kernt et al., 2012 ⁴⁶ | Germany | Comparative study | Seven-field stereo ETDRS standard versus ultrawide field scanning laser ophthalmoscopy | Instant grading | DM duration over 3 years | Local |
| Liegl et al., 2014 ⁴⁷ | Germany | Comparative study | Non-mydratic ultrawide field versus mydratic two-field 45° colour fundus photography | Instant grading | DM for at least 3 years | Local |
| Expert Advisory Group National Retinopathy Screening Committee, 2008 | Ireland | National programme/framework, did not start | Digital photography stationary and mobile | Telemedicine | Patient age 12 years old and over | Population based |
| McHugh et al., 2013 ⁵¹ | Ireland | National programme | Digital fundus camera/two-fields photography | Telemedicine | Patient age 18 years old and over | Population based |

Table 2: Countries Outside Europe

| Authors | Country | Type of Study | Screening Method | Instant Grading/ Telemedicine | Covered Population | Population |
|---|----------------|---|--|---------------------------------------|---|-------------------------------|
| Cuadros et al., 2009 ²⁴ | California, US | Pilot programme | Digital retinal colour pictures, three-fields | Telemedicine | No data | No data |
| Owsley et al., 2015 ²⁵ | US | Cross-sectional study | Digital retinal colour pictures, two-fields | Telemedicine | 18 years old or over type 1 and 2 DM | Local |
| Mansberger et al., 2015 ²⁹ | US | Randomised clinical trial | Digital retinal colour pictures, six 45° pictures of macula (stereo), optic disc (stereo) and peripheries (non-stereo) | Telemedicine | Patients with DM 18 years old or older | Local |
| Nathoo et al., 2010 ⁴² | Canada | Retrospective consecutive case series | Seven-field colour, stereoscopic, digital photography | Telemedicine | Patients with DM | Local |
| Khan et al., 2007 ³⁹ | South Africa | Regional programme | Digital retinal colour pictures, mobile station | Instant grading | Uninsured and low socio-economic backgrounds patients | Local |
| Cook, 2013 ⁴¹ | South Africa | National Diabetic Retinopathy Screening Programme/ Ophthalmology Society of Southern Africa | Digital retinal colour pictures, single, central-field | Telemedicine | Population based | Internet DR data-based system |
| Levy et al., 2011 ⁴⁵ | Israel | Pilot clinical trial | Digital retinal colour pictures, at least two-fields, 45° mobile station | Telemedicine | Diabetic members of Israel health fund – Clalit | Local/South Israel |
| Lau et al., 1995 ⁴⁷ | Singapore | National programme | Retinal colour pictures, 45° | Instant grading | Government diabetic clinic patients | National |
| Lim et al., 2008 ⁴⁸ | Singapore | National programme | Digital retinal colour pictures, one-field, 45° | Instant grading | Patients referred to primary care clinics | National |
| Liu et al., 2003 ⁴⁹ | Taiwan | Clinical trial | Ophthalmoscopy or fluorescein angiography | Instant grading | Patients of one Taipei clinic | Local |
| Mak et al., 2003 ⁵⁴ Murray et al., 2005 ⁵⁵ | Australia | Local programmes | Retinal photography with Polaroid film | Instant grading or in grading centres | Patients of Western Australia | Local |

DM = diabetes mellitus; DR = diabetic retinopathy; ETDRS = Early Treatment Diabetic Retinopathy Study.

Israel

Levy et al. described a study on DR screening in Southern Israel.⁴⁴ They described a service for DR screening with the use of the Topcon mobile non-mydratric fundus camera. A trained photographer took at least two 45° images of retina-covering macula, optic disc and superior and temporal fields. The TIFF format pictures were sent to a grading server and within 2 weeks graded by the same doctor. They concluded that mobile digital photography increased the possibility of detecting sight-threatening DR.

Germany

Kernt et al. conducted a study on DR screening comparing ETDRS seven-field stereo standard versus one ultrawide field scanning laser ophthalmoscopy (Optomap).⁴⁵ They showed that the Optomap system did not need to dilate the pupil, the skills of the photographer may be not as good as the ETDRS standard and the efficiency of assessment DR is comparable. They concluded that ultrawide scanning laser ophthalmoscopy might be a promising alternative for DR screening.

The authors from the same university also compared ultrawide field scanning laser ophthalmoscopy with two-field fundus photography in DR screening.⁴⁶ They showed that ultrawide field ophthalmoscopy might be potentially better in DR screening, but it required further study.

Singapore

Mass screening for DR in Singapore started in 1991.⁴⁷ The founders of that programme chose Polaroid non-mydratric 45° Topcon fundus photography because of an ophthalmologist was not required to take a picture. At that time the method was relatively cheap and suitable for mass screening. Pictures were taken by a trained photographer, usually after mydriasis and graded by hospital ophthalmologist. It was the first-in-the-world nationwide programme for DR screening.

Lim et al. showed in their study review of suspected DR patients sent to tertiary referral clinic from the Nationwide Screening Programme.⁴⁸ The programme is based on a one-field digital 45° image of central retina, performed annually in all patients with diabetes in Singapore.

They found that one of three patients have any kind of DR and only one of nine patients has sight-threatening DR. The screening programme used a Topcon fundus camera and the pictures were graded by trained family doctors.

Taiwan

Liu et al. presented a study on DR screening in an outpatient clinic performed between 1 January 1990 till 31 December 1992.⁴⁹ They used ophthalmoscopy or fluorescein angiography for DR evaluation. The authors suggested that DR screening is worthwhile.

Ireland

In 2007 in Ireland, the Diabetes Expert Advisory Group was established to develop a national, population-based DR screening programme.⁵⁰ The group created a framework for DR screening: it was never implemented.

When this screening programme did not begin, in 2003 McHugh et al. presented a study for DR screening in primary care in Ireland.⁵¹ They described Diabetes in General Practice (DiGP), a community-based initiative established in 2010, involving GPs, local optometrists and ophthalmologists. They screened patients with diabetes type 1 or 2, aged 18 or more with the use of digital fundus cameras. They took two-field pictures of the retina (macula and optic disc). The pictures were graded by MDTs software and the results in electronic records were sent to GPs, who were responsible for referring patients to the ophthalmic specialists. The study was conducted from 1 January until 30 June 2011 and found 26 % patients with DR. So they concluded the need for a national DR screening programme in Ireland.

Hungary

Szabó et al. presented a telemedical study on DR screening.⁵² They used three-field digital 45° retina photographs. Pictures were sent via Internet to the grading centre and an independent ophthalmologist assessed DR status. They used a non-mydratric fundus camera, but also performed pupil dilatation and ophthalmoscopy if needed.

Czech Republic

The Czech National Diabetes Programme 2012–2022⁵³ also covers DR screening with the use of photography of retina. However, currently there is not enough information on this study.

Australia

It is a large country with many dispersed small towns and communities of people. This is why the DR screening is hard to carry out. Mak et al.⁵⁴ and Murray et al.⁵⁵ reported a DR-screening scheme in the Kimberly region of Western Australia. They described DR screening with the use of a non-mydratric fundus camera 45°, but with Polaroid film. They did not use digital cameras because of difficulties with electricity in some places of examination. They used mobile cameras with instant grading of retinal pictures. Photographs were taken with mydriasis.

Portugal

One of the newest DR screening programmes study was reported by Dutra Medeiros et al.⁵⁶ They worked in the Study Group for Diabetic Retinopathy Screening (RETINODIAB) in Lisbon and Tagus Valley area from July 2009 till October 2014. The screening programme was held in several primary healthcare units with 45° non-mydratric fundus cameras. They took two pictures of the retina: one of the macula centre; the second of the optic disc. When problems with good quality pictures were experienced, they performed pharmacological pupil

dilatation. Photographs after compression in the DICOM format were sent to the grading centre, where they were assessed according to the International Clinical Diabetic Retinopathy Scale. The study group suggested that this screening method could be an effective technique for early DR detection.

Poland

There are standards for patients with diabetes care, prepared by the Polish Diabetologist Society.⁵⁷ The authors suggest that DR should be screened regularly, but there is no national programme for population-based DR screening.

The Polish National Health Fund (NFZ) recommend diabetic eye screening (with retina examination) performed by ophthalmologists in Complex Out-Patient Specialistic Care for Diabetes Mellitus (KAOS). This service does not include national population-based DR screening.⁵⁸

Discussion

There are different methods of DR screening in the world. Direct and indirect ophthalmoscopy is used, as well as different kinds of retinal photography.^{11–55} Conventional photography of the retina was used in early 1990 in Singapore.⁴⁸ The digital photography of the eye fundus seems to be the most efficient and cost-effective. Retinal pictures are solid proof of the status of the retina and can be graded once again if needed. The gold standard for retinal diabetic photography is a seven-field stereo colour ETDRS standard,⁵⁹ but this type of the fundus photography is time-consuming, expensive and requires an experienced photographer. The screening process should be: 'economically balanced in relation to possible expenditure on medical care as a whole'⁶ and this condition is made by digital, non-stereo retinal photography. There are also variations of this kind of photography, from seven-field colour retinal photography recommended by the American Diabetes Association (ADA)²⁷ and trained in Canada,²⁵ to five-field photography^{30,31,34} performed in France and Spain. There are also four-field photographs of the retina^{37,38} taken in Spain and three-field retinal images^{24,33,34} (also in France and in the US). The most-often used method is two-field pictures of the retina: performed in the UK, USA, Israel and Ireland.^{11,12,16–18,25,44,51} Similarly, only one picture of the retina is used in Scotland,²¹ Spain,³⁶ South Africa⁴¹ and Singapore.⁴⁸ A special type of one-field retinal picture in the German project is the use of one, ultrawide picture taken by Optomap,^{45,46} which is an interesting alternative for two-field photography. The intervals between eye examinations in the above-mentioned studies are based on the severity of the retinal changes. There are recent studies and programmes that personalise intervals of screening timing not only on retinal status but also on DM control, e.g. blood glucose control (HbA_{1c}), blood pressure, patient gender, type of DM and duration of DM.^{60,61} Mehlsen et al. in Denmark and Stefansson et al. in Iceland introduced this approach for screening intervals. It allows screening to be more cost-effective through extending the length between examinations to more than 1 year for mild stages of DR. It helps also to avoid excessive retinal treatment.

Mansberger et al.²⁹ compared telemedicine DR screening to traditional retina examination. They showed that telemedicine increased the percentage of DR screening examinations. They concluded that remote DR screening could be performed by primary care clinics.

One of the most important reasons for the use telemedicine in ophthalmology is the lack of retina specialists, even in developed countries. The use of remote assessment of retina pictures allows

this problem to be managed (few doctors screen a large area). Dutra Medeiros et al. remarked on this problem in their study.⁵⁶

In conclusion, it can be argued that DR screening programmes are developed all over the world, especially in developed countries. These programmes help to detect early sight-threatening DR, treat it in a timely fashion and in this way avoid expensive, advanced treatment or even

prevent blindness developing among working age people. In summary, we can conclude that a good DR screening programme is simple, easy to perform, cheap, covering more than 80 % of patients, and protecting against serious complications. After a review of current DR studies, we recommend DR screening with the use of colour, two-field retina photography taken by technicians with the non-mydratic fundus cameras, with telemedicine software and graded in centres by retina specialists. ■

- Jönsson B, CODE-2 Advisory Board, Revealing the cost of Type II diabetes in Europe, *Diabetologia*, 2002;45:55–12.
- Williams R, Van Gaal L, Lucioni C, CODE-2 Advisory Board, Assessing the impact of complications on the costs of Type II diabetes, *Diabetologia*, 2002;45:13–7. Epub 2002 Jun 12.
- International Diabetes Federation. IDF Diabetes Atlas, 6th ed. Brussels, Belgium: International Diabetes Federation; 2013. Available from: <http://www.idf.org/diabetesatlas> (accessed 26 June 2014).
- Kempner JH, O'Colmain BJ, Leske MC, et al., Eye Diseases Prevalence Research Group. The prevalence of diabetic retinopathy among adults in the United States, *Arch Ophthalmol*, 2004;122:552–63.
- Congdon NG, Friedman DS, Leitman T, Important causes of visual impairment in the world today, *JAMA*, 2003;290:2057–60.
- Fong DS, Aiello LP, Ferris FLIII, Klein R, Diabetic retinopathy, *Diabetes Care*, 2004;27:2540–53.
- Ockrim Z, Yorston D, Managing diabetic retinopathy, *BMJ*, 2010;341:c5400.
- Wilson J, Jungner G, The principles and practice of screening for disease, *Public Health Papers*, Geneva: WHO, 1968.
- Diabetes care and research in Europe: the Saint Vincent declaration, *Diabet Med*, 1990;7:360.
- Screening for diabetic retinopathy in Europe 15 years after the St Vincent Declaration. The Liverpool Declaration 2005. Report of conference 17–18 November 2005. Available at: <http://reseau-ophdiat.aphp.fr/Document/Doc/confliverpool.pdf> (accessed 13 July 2015).
- The Royal College of Ophthalmologists. Diabetic retinopathy guidelines (added 12 December 2012). Available at: www.rcophth.ac.uk (accessed 13 July 2015).
- NDESP. Available at: <http://diabeticeye.screening.nhs.uk/> (accessed 13 July 2015).
- SDRSC. Available at: <http://www.ndrs.scot.nhs.uk> (accessed 13 July 2015).
- DRSSW. Available at: <http://www.cardiffandvaleuhb.wales.nhs.uk/drsw> (accessed 13 July 2015).
- NIDRSP Northern Ireland DR Screening Programme Annual report 2008–09, 2010. Available at: <http://www.publichealth.hscni.net/publications/northern-ireland-diabetic-retinopathy-screening-programme> (accessed 13 July 2015).
- NHS public health functions agreement 2015–16 Service specification no.22 NHS Diabetic Eye Screening Programme. Public Health England. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/383196/1516_No22_NHS_Diabetic_Eye_Screening_Programme_FINAL.pdf (accessed 13 July 2015).
- Thomas RL, Dunstan FD, Luzzio SD, et al., Prevalence of diabetic retinopathy within a national diabetic retinopathy screening service, *Br J Ophthalmol*, 2015;99:64–8.
- Garvican L, Clowes J, Gillow T, Preservation of sight in diabetes: developing a national risk reduction programme, *Diabet Med*, 2000;17:9627–34.
- Harding S, Greenwood R, Aldington S, et al., Grading and disease management in national screening for diabetic retinopathy in England and Wales, *Diabetic Med*, 2003;20:965–71.
- A protocol for screening for diabetic retinopathy in Europe. Retinopathy Working Party, *Diabetic Med*, 1991;8:263–7.
- Scottish Diabetic Retinopathy Grading Scheme 2007; Scottish Diabetic Retinal Screening Collaborative. 2007. Available at: <http://www.ndrs.scot.nhs.uk/ClinGrp/Docs/Grading%20Scheme%202007%20v1.1.pdf> (accessed 13 July 2015).
- Philip S, Cowie LM, Olson JA, The impact of the Health Technology Board for Scotland's grading model on referrals to ophthalmology services, *Br J Ophthalmol*, 2005;89:891–6.
- Fleming AD, Goatman KA, Philip S, et al., Automated grading for diabetic retinopathy: a large-scale audit using arbitration by clinical experts, *Br J Ophthalmol*, 2010;94:1606–1610.
- Cuadros J, Bresnick G, EyePACS: an adaptable telemedicine system for diabetic retinopathy screening, *J Diabetes Sci Technol*, 2009;3:509–16.
- Owsley C, McGwin Jr G, Lee DJ, et al., for the Innovative Network for Sight (INSIGHT) Research Group, Diabetes eye screening in urban settings serving minority populations. Detection of diabetic retinopathy and other ocular findings using telemedicine, *JAMA Ophthalmol*, 2015;133:174–81.
- Harding S, Greenwood R, Aldington S, et al., Diabetic Retinopathy Grading and Disease Management Working Party. Grading and disease management in national screening for diabetic retinopathy in England and Wales, *Diabet Med*, 2003;20:965–71.
- American Diabetes Association, Diabetic retinopathy, *Diabetes Care*, 2002;(Suppl. 1).
- Byrne MM, Parker DF, Tannenbaum SL, et al., Cost of a community-based diabetic retinopathy screening program, *Diabetes Care*, 2014;37:e236–7.
- Mansberger SL, Sheppler C, Barker G, et al., Long-term comparative effectiveness of telemedicine in providing diabetic retinopathy screening examinations: A randomized clinical trial, *JAMA Ophthalmol*, 2015;133:518–25.
- Massin P, Aubert JP, Erginay A, et al., Screening for diabetic retinopathy: the first telemedical approach in a primary care setting in France, *Diabetes Metab*, 2004;30:451–7.
- Massin P, Aubert JP, Eschwege E, et al., Evaluation of a screening program for diabetic retinopathy in a primary care setting Dodia (Dépistage ophtalmologique du diabète) study, *Diabetes Metab*, 2005;31:153–62.
- Schulze-Döböld C, Erginay A, Robert N, et al., Ophdiat@: five-year experience of a telemedical screening programme for diabetic retinopathy in Paris and the surrounding area, *Diabetes Metab*, 2012;38:450–7.
- Deb-Joardar N, Germain N, Thuret G, et al., Systematic screening for diabetic retinopathy with a digital fundus camera following pupillary dilatation in a university diabetes department, *Diabet Med*, 2007;24:303–7.
- Creuzot-Garcher C, Malvitte L, Sicard AC, et al., How to improve screening for diabetic retinopathy: the Burgundy experience, *Diabetes Metab*, 2010;36:114–9.
- Andonegui J, Zurutuza A, de Arcelus MP, et al., Diabetic retinopathy screening with non-mydratic retinography by general practitioners: 2-year results, *Prim Care Diabetes*, 2012;6:201–5.
- Gibelalde A, Ruiz-Miguel M, Mendicute J, et al. [Prevalence of diabetic retinopathy using non-mydratic retinography, *An Sist Sanit Navar*, 2010;33:271–6.
- Vleming EN, Castro M, López-Molina MI, Teus MA, Use of non-mydratic retinography to determine the prevalence of diabetic retinopathy in diabetic patients, *Arch Soc Esp Oftalmol*, 2009;84:231–6.
- Gómez-Ulla F, Fernandez MI, Gonzalez F, et al., Digital retinal images and teleophthalmology for detecting and grading diabetic retinopathy, *Diabetes Care*, 2002;25:1384–9.
- Khan T, Bertram MV, Jina R, et al., Preventing diabetes blindness: cost effectiveness of a screening programme using digital non-mydratic fundus photography for diabetic retinopathy in a primary health care setting in South Africa, *Diabetes Res Cl Pract*, 2013;101:170–6.
- Mash B, Powell D, du Plessis F, et al., Screening for diabetic retinopathy in primary care with a mobile fundal camera—evaluation of a South African pilot project, *S Afr Med J*, 2007;97:1284–8.
- Cook S, Diabetic retinopathy – the Ophthalmology Society of Southern Africa screening programme, *S Afr Med J*, 2013;103:449–51.
- Nathoo N, Ng M, Rudnisky CJ, Tennant MT, The prevalence of diabetic retinopathy as identified by teleophthalmology in rural Alberta, *Can J Ophthalmol*, 2010;45:28–32.
- Lemmetty R, Mäkelä K, Mobile digital fundus screening of type 2 diabetes patients in the Finnish county of South-Ostrobothnia, *J Telemed Telecare*, 2009;15:68–72.
- Levy J, Lifshitz T, Goldfarb D, et al., Screening for diabetic retinopathy with a mobile non-mydratic digital fundus camera in southern Israel, *Isr Med Assoc J*, 2011;13:137–40.
- Kernit M, Hadl I, Pinter F, et al., Assessment of diabetic retinopathy using nonmydratic ultra-widefield scanning laser ophthalmoscopy (Optomap) compared with ETDRS 7-field stereo photography, *Diabetes Care*, 2012;35:2459–63.
- Liegl R, Liegl K, Cekić L, et al., Nonmydratic ultra-wide-field scanning laser ophthalmoscopy (Optomap) versus two-field fundus photography in diabetic retinopathy, *Ophthalmologica*, 2014;231:31–6.
- Lau HC, Voo YO, Yeo KT, et al., Mass screening for diabetic retinopathy—a report on diabetic retinal screening in primary care clinics in Singapore, *Singapore Med J*, 1995;36:510–3.
- Lim MC, Lee SY, Cheng BC, et al., Diabetic retinopathy in diabetics referred to a tertiary centre from a nationwide screening programme, *Ann Acad Med Singapore*, 2008;37:753–9.
- Liu WJ, Lee LT, Yen MF, et al., Assessing progression and efficacy of treatment for diabetic retinal screening in the proliferative pathway to blindness: implication for diabetic retinopathy screening in Taiwan, *Diabet Med*, 2003;20:727–33.
- Expert Advisory Group National Retinopathy Screening Committee. Framework for the development of a diabetic retinopathy screening programme for Ireland. Naas: Health Service Executive, 2008.
- McHugh S, Buckley C, Murphy K, et al., Quality-assured screening for diabetic retinopathy delivered in primary care in Ireland: an observational study, *Br J Gen Pract*, 2013;63:e134–40.
- Szabó D, Fiedler O, Somogyi A, et al., Telemedical diabetic retinopathy screening in Hungary: a pilot programme, *J Telemed Telecare*, 2015;21:167–73.
- Pelikánová T, Diabetic retinopathy in the Czech National Diabetes Programme 2012–2022, *Vnitř Lek*, 2013;59:214–7. [Article in Czech]
- Mak DB, Plant AJ, McAllister I, Screening for diabetic retinopathy in remote Australia: a program description and evaluation of a devolved model, *Aust J Rural Health*, 2003;11:224–30.
- Murray RB, Metcalf SM, Lewis PM, et al., Sustaining remote-area programs: retinal camera use by Aboriginal health workers and nurses in a Kimberley partnership, *Med J Aust*, 2005;182:520–3.
- Dutra Medeiros M, Mesquita E, Papoila AL, et al., First diabetic retinopathy prevalence study in Portugal: RETINODIAB Study—Evaluation of the screening programme for Lisbon and Tagus Valley region, *Br J Ophthalmol*, 2015 [Epub ahead of print]. Polish Diabetologist Society. Available at: http://www.cukrzyca.info.pl/zalecenia_kliniczne/zalecenia_kliniczne_dotczyzace_postepowania_u_chorych_na_cukrzyce_2014 (accessed 13 July 2015).
- Polish National Health Fund. Available at: <http://www.nfz.gov.pl/zarzadzenia-prezesa/zarzadzenia-prezesa-nfz/zarzadzenie-nr-802008dsoz,3442.html> (accessed 13 July 2015).
- Early Treatment Diabetic Retinopathy Study Research Group. Photocoagulation therapy for diabetic eye disease, *JAMA*, 1985;254:3086.
- Available at: Retinarisk.com (accessed 15 July 2015).
- Mehlsen J, Eriandson M, Poulsen PL, Bek T, Individualized optimization of the screening interval for diabetic retinopathy: a new model, *Acta Ophthalmol*, 2012;90:109–14.