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To cite this article: Robyn J. Tapp, Jean Svoboda, Bronwyn Fredericks, A. Jonathan Jackson & Hugh R. Taylor (2015) Retinal Photography Screening Programs to Prevent Vision Loss from Diabetic Retinopathy in Rural and Urban Australia: A Review, *Ophthalmic Epidemiology*, 22:1, 52-59, DOI: [10.3109/09286586.2014.988875](https://doi.org/10.3109/09286586.2014.988875)

To link to this article: <http://dx.doi.org/10.3109/09286586.2014.988875>



Published online: 12 Dec 2014.



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ORIGINAL ARTICLE

# Retinal Photography Screening Programs to Prevent Vision Loss from Diabetic Retinopathy in Rural and Urban Australia: A Review

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## ABSTRACT

**Purpose:** This review assessed the effectiveness of diabetic retinopathy (DR) screening programs, using retinal photography in Australian urban and rural settings, and considered implications for public health strategy and policy.

**Methods:** An electronic search of MEDLINE, PubMed, and Embase for studies published between 1 January 1996 and the 30 June 2013 was undertaken. Key search terms were “diabetic retinopathy,” “screening,” “retinal photography” and “Australia.”

**Results:** Twelve peer-reviewed publications were identified. The 14 DR screening programs identified from the 12 publications were successfully undertaken in urban, rural and remote communities across Australia. Locations included a pathology collection center, and Indigenous primary health care and Aboriginal community controlled organizations. Each intervention using retinal photography was highly effective at increasing the number of people who underwent screening for DR. The review identified that prior to commencement of the screening programs a median of 48% (range 16–85%) of those screened had not undergone a retinal examination within the recommended time frame (every year for Indigenous people and every 2 years for non-Indigenous people in Australia). A median of 16% (range 0–45%) of study participants had evidence of DR.

**Conclusions:** This review has shown there have been many pilot and demonstration projects in rural and urban Australia that confirm the effectiveness of retinal photography-based screening for DR.

**Keywords:** Australia, diabetic retinopathy, retinal photography, rural and urban

## INTRODUCTION

Vision loss and blindness from diabetic retinopathy (DR) are almost entirely preventable.<sup>1</sup> The international community through the establishment of Vision 2020 aim to eliminate avoidable blindness worldwide. Screening for DR has been shown to not only reduce the number of people who develop vision

loss and blindness, but also to be very cost effective.<sup>2</sup> The costs of providing preventative eye care are much lower than the costs associated with ongoing support and rehabilitation required due to vision loss and blindness.<sup>2</sup> In Australia, each \$1 spent on eye care yields a \$5 return.<sup>2</sup>

Despite the literature highlighting the effectiveness of early detection and treatment of DR,

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Received 26 February 2014; Revised 4 September 2014; Accepted 7 September 2014; Published online 12 December 2014

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population-based studies in Australia and internationally have shown that only approximately half of those with diabetes undergo regular screening for DR.<sup>3</sup> The National Health and Medical Research Council (NHMRC) of Australia guidelines recommend that non-Indigenous people undergo an eye examination at diagnosis and biannually thereafter and at diagnosis and annually for Indigenous people with diabetes.<sup>4</sup> DR screening within the recommended timeframe for Indigenous Australians is only 20%.<sup>5</sup>

The incidence of diabetes is increasing throughout the world. Although good glycemic, blood pressure and lipid control reduces the incidence of DR, all people with diabetes are at risk of developing DR. This review assessed the effectiveness of DR screening programs using retinal photography, and assessed the education, training and development of resources and equipment related to DR screening, in Australian urban and rural settings, and considered implications for public health strategy and policy.

## MATERIALS AND METHODS

An electronic search of MEDLINE, PubMed, and Embase for studies published between 1 January 1996 and 30 June 2013 was undertaken. Studies that employed a screening program for DR using retinal

photography in Australia were included. There was no restriction on sample size or duration of the intervention. Key search terms used were “diabetic retinopathy,” “screening,” “retinal photography” and “Australia.” In addition, a search of program documents developed by national organizations in Australia was performed, using the key search terms above and corresponded with key stakeholders known to have worked in the area. We further searched the reference lists of the main papers for additional publications of interest. The article search and selection process are shown in Figure 1. Each full-text paper was examined for eligibility and all relevant information extracted (including study location, sample size, recruitment strategy, response rates, type of retinal camera, intervention method and effectiveness of the intervention). The final unit of measurement was “projects” (the series of projects undertaken in Western Australia were not all individually published, but rather collated in one publication). Inclusion of published projects was determined by consensus between authors. Programs assessing education, training, resource development and equipment related to screening for DR identified from the literature search were also extracted. The term effectiveness in this review refers to the ability of the screening programs to identify those with diabetes who had not undergone an eye examination within the recommended time frame.

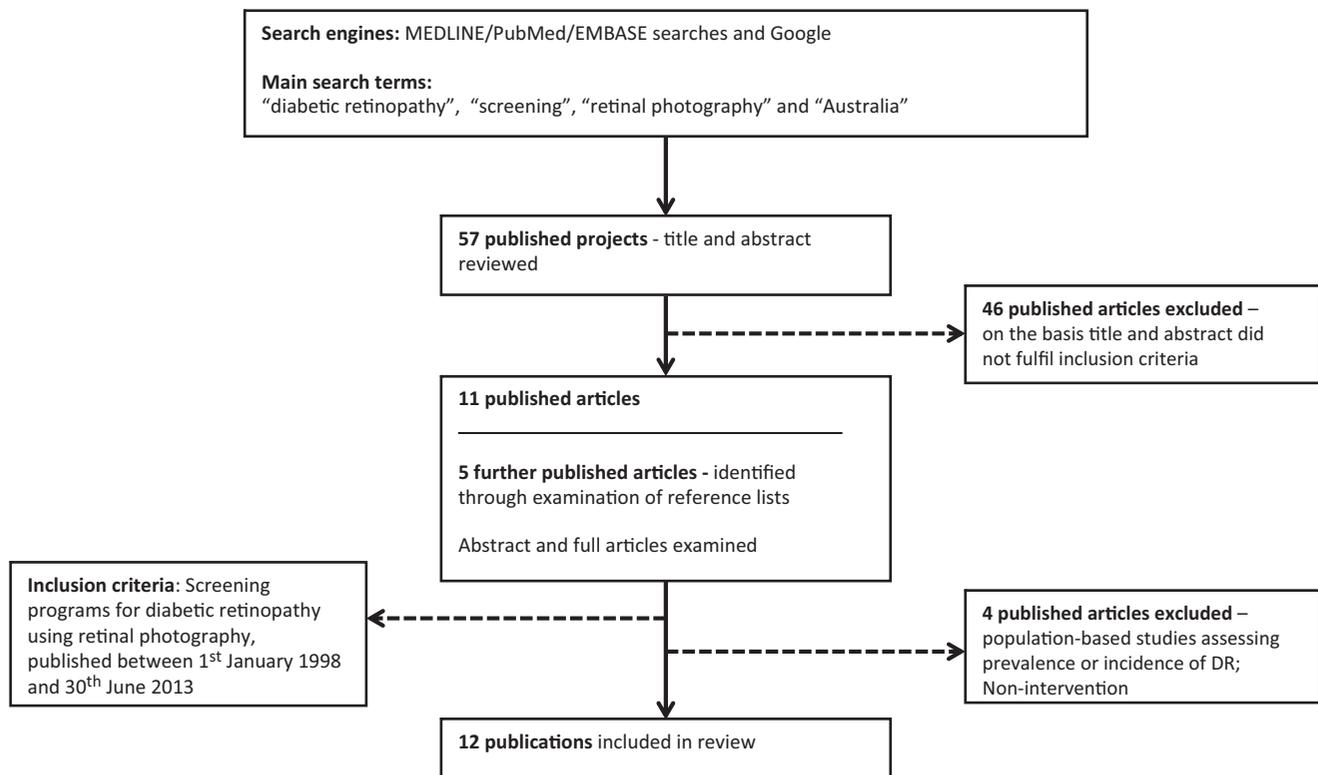


FIGURE 1. Literature search strategy to identify projects assessing the effectiveness of diabetic retinopathy screening programs in Australia.

## RESULTS

The search identified 57 peer-reviewed papers. After review of titles and abstracts, 46 published articles were excluded, on the basis of the titles and abstracts not fulfilling the inclusion criteria. Eleven published articles were included in this review. A search of program documents developed by national organizations in Australia identified an additional project, and a further five published articles were identified through examination of the reference lists. A total of 17 publications underwent a full review. Of these, four were excluded as they were population-based studies assessing prevalence or incidence of DR or were non-intervention studies and one study had yet to commence, providing a total of 12 publications for review. The main findings of the 14 projects, identified in the 12 publications are shown in Table 1. Findings are divided into three sections: (1) sample characteristics, (2) intervention program characteristics, and (3) effectiveness of the programs, including the percentage of subjects included who had not been screened in the recommended time frames, number of new cases of DR detected and number of DR cases receiving appropriate care after screening. The second non-extensive search identified 12 projects assessing education, training and development of resources and equipment related to DR screening in Australia.

### Sample Characteristics

The review identified 14 projects in Australia, assessing screening programs for DR. The projects were undertaken in primary health care and community settings with four studies using telemedicine (Table 1). Sample sizes ranged from 10–1589 participants with an age range of 6–100 years. Of the articles, only five stated duration of diabetes, which ranged from 1–61 years. The projects were undertaken in a range of setting including urban populations,<sup>6–11</sup> rural and remote communities<sup>3,7,8,12–14</sup> and regional areas.<sup>6,8,15</sup> Locations included a pathology collection center,<sup>10</sup> Indigenous primary health care,<sup>9</sup> general practice,<sup>8,11</sup> prison,<sup>12</sup> mobile unit set up in the community,<sup>3,6,7,12,14,16</sup> Aboriginal community controlled organizations<sup>12,13</sup> and telemedicine.<sup>15</sup> Each study used retinal photography.

### Intervention Program Characteristics

The studies undertook a number of approaches to recruit participants for DR screening. For example, the study by Larizza and colleagues recruited participants from a pathology collection center.<sup>10</sup> Participants were included if they met the eligibility criteria type 1 or type 2 diabetes, spoke English, and did not undertake

biannual DR screening. A number of studies opportunistically recruited participants, attending general practice for their annual cycle of care visit.<sup>9,11,14</sup> One study undertook an audit of electronic participant records.<sup>13</sup> Another approach taken was to recruit through pediatric diabetes clinics.<sup>15</sup> A population-based study selected all residents with diabetes mellitus residing in particular areas defined by postal codes. Recruitment strategies included contact with general practitioners, printed media, radio broadcasts, contacting migrant resource centers and presentations to senior citizen groups.<sup>3,6,7</sup>

### Effectiveness of Interventions

The review identified that prior to commencement of the screening programs a median of 48% (range 16–85%) of those screened had not undergone a retinal examination within the recommended time frame (2-yearly for non-Indigenous people and yearly for Indigenous people). A median of 16% (range 0–45%) of study participants had evidence of DR. Limited data were available on care received after diagnosis of DR through the screening programs. The three studies that did record this detail varied greatly in the percentage receiving follow-up care (33–93%).

Coverage of screening varied between health services within a region (from 12–65%).<sup>14</sup> The studies showed that when a screening program was offered, patient acceptance rates increased. For example, DR screening in Indigenous primary care increased 6-fold with the introduction of a DR screening program,<sup>9</sup> and in a study by Lee and co-workers, where none of the study participants had previously accessed eye care services on a regular basis, 87% did so after attending a DR screening program.<sup>7</sup> Screening for DR at a pathology collection service showed that 34% had not undergone retinopathy screening in the recommended time frame, but when offered screening 94% accepted.<sup>10</sup> In the mobile, community-based screening program, 652 people who had not undergone previous DR screening in the recommended time frame, agreed to, and took part in the baseline screening.<sup>7</sup> Two years after baseline screening, 87% of participants returned to the screening, or reported that they had a subsequent eye examination. None of the studies reported on the number of cases receiving appropriate care after screening.

### Educational Activities, Training and the Development of Resources related to DR Screening

#### Patient Education and DR Awareness

Table 2 provides a summary of Australian projects assessing education, training and the development of

TABLE 1. Summary of Australian projects assessing effectiveness of diabetic retinopathy (DR) screening programs.

Project	Location	Retinal camera	Participants, n	Not screened for DR prior to study, %	DR diagnosed, %	Care after DR diagnosis, %	Time frame	Key study outcome
Mobile DR screening <sup>16</sup>	South Australia	-	47	-	-	-	1996	Of 47 subjects who attended, 77% had interpretable images.
Community DR screening: 2-year follow-up <sup>6</sup>	Victoria	Canon CR5-45NM	1197	52	-	-	1996-1998	Screening program for people with diabetes able to increase compliance with guidelines.
Community DR screening <sup>7</sup>	Victoria	Non-mydiatic retinal camera	543	100 <sup>r</sup>	16	87	1996-2000	None of the participants in the study had previously accessed eye care services on a regular basis, 87% did so after attending screening.
DR screening in rural Victoria <sup>3</sup>	Victoria	Canon CR5-45NM	1177	48	18	-	1998	48% of those who attended the service could not recall a dilated fundus examination in the past 2 years.
Eye Health Coordinators Project <sup>12</sup>	Across 5 regions of Western Australia	Canon CR5 and CR6-45NM	1498	-	17	-	1998 to date	The state-wide screening program was implemented in 2004. 58% of those with known diabetes were regularly screened, surpassing programs in less remote areas.
Regional DR screening program <sup>13</sup>	Kimberley Region, Western Australia	Canon CR4-UAF	1589	84 (Indigenous, <9 months <sup>a</sup> ), 16 (non-Indigenous, 9-29 months <sup>a</sup> )	21 11	-	1999-2004	Screening for DR by Aboriginal health workers can be successfully sustained with regional support.
DR screening in the Kimberley <sup>4</sup>	Kimberley Region, Western Australia	Canon CR5-45	744	-	-	33 within 4 months	2000-2001	DR screening in remote Australia is comparable to, or higher than, other urban or rural populations.

(continued)

TABLE 1. Continued

Project	Location	Retinal camera	Participants, <i>n</i>	Not screened for DR prior to study, %	DR diagnosed, %	Care after DR diagnosis, %	Time frame	Key study outcome
Prison DR screening: telemedicine <sup>30</sup>	Western Australia	Retinal camera	10	–	0	–	2001	Telemedicine DR screening of inmates reduced travel time and was deemed successful.
Telepediatrics: DR screening <sup>15</sup>	Regional hospitals, Queensland	Handy NM-200, Nidek, Japan	83	35	1.2	–	2004	Study demonstrated feasibility of a screening service for DR using a portable digital retinal camera.
DR screening: telemedicine <sup>12</sup>	Gascoyne, Western Australia	Canon CR6-45NM	43	–	45	–	2004	36% of patients required follow-up, 3% had treatment at the remote site and 3% were transferred to Perth.
DR screening: Pilbara Western Desert <sup>12</sup>	Pilbara, Western Australia	Canon CR6 45NM	77	–	16	–	2005–2006	15.6% of those presenting for DR screening had DR; Outlined technical and practical difficulties.
Pilot DR screening: general practice <sup>11</sup>	Queensland	Canon CR-1 NM	114	–	12	–	2007–2008	General practice-based DR screening was feasible and acceptable, but photographic quality was an issue.
DR screening: Indigenous primary care <sup>9</sup>	Inala, Queensland	Canon CR-Dgi	132	85	30	93	2007–2009	Appropriate screening and ophthalmic follow-up increased 6-fold, following the introduction of the retinal camera.
DR screening: pathology services <sup>10</sup>	Melbourne, Victoria	Non-mydiatric retinal camera	93	–	17	–	2009–2010	Of 289 patients with diabetes who came through the service, 34.3% had not had recommended DR screening; 93.9% ( <i>n</i> = 93) of those accepted a screening service. Median photography time was 6 minutes.

–, no data. <sup>a</sup>Time frame to retinal screening

TABLE 2. Summary of Australian projects assessing education, training and development of resources and equipment related to screening for diabetic retinopathy (DR). NHMRC, National Health and Medical Research Council.

Project	Location	Time frame	Outcome
Mobile DR screening approaches: The Victorian Retinopathy Screening Development Project <sup>17</sup>	Victoria	1998–2001	Developed a suitable approach to mobile screening for rural areas.
Development of a small retinal-screening device <sup>20</sup>	Western Australia	2001–2007	Successfully developed a low-cost, small DR screening device.
Pilot to assess the impact of DR training on general practitioner practice <sup>18</sup>	Queensland	2001	24% of general practitioners met the NHMRC criteria prior to training and 94% following a brief training intervention.
National framework to prevent avoidable blindness (DR, AU\$4 million) <sup>31</sup>	National	2005–2008	The 2008 report highlights the many projects and progress made by each.
Ophthalmic nurse-led DR clinic <sup>32</sup>	South Australia	2006	Excellent concordance between nurse practitioners and ophthalmologists was achieved.
Tele-health using EyeScan for DR screening <sup>33</sup>	Western Australia	2011	–
Video-based imaging for DR screening <sup>34</sup>	Western Australia	2012	Retinal video recording at different compression levels was an effective DR screening technique.
Evaluation of DR education resources <sup>35</sup>	Western Australia	2012–2015	–
Raise awareness of diabetes and DR <sup>36</sup>	Victoria	2012	–
Novel device for DR screening <sup>37</sup>	Western Australia	2012	EyeScan required minimal training and had excellent diagnostic accuracy.
Tele-ophthalmic eye screening and treatment program for DR <sup>21</sup>	Dubbo, New South Wales	–	Program provides tele-ophthalmic eye screening and treatment for DR.
Project to train an Aboriginal health worker in DR screening <sup>38</sup>	Katherine, Northern Territory	–	–

resources and equipment related to screening for DR. The search identified 12 projects focused on aspects of screening for DR. The Victorian Retinopathy Screening Development Project, identified a lack of awareness of the role optometrists can play in DR screening, and after an awareness campaign, knowledge increased among general practitioners on the role optometrists can perform.<sup>17</sup>

#### Training of Non-ophthalmologist Health Care Providers and their Roles in DR Screening

Short training programs improved the ability of health workers to screen for DR.<sup>18</sup> Community awareness campaigns increased knowledge and participation in DR screening programs.<sup>19</sup>

#### Screening Tools/Devices, Venues and Referral Channels

Portable equipment that is both cheap and easy to use has been successfully made in Australia.<sup>20</sup> Telemedicine has been shown to provide a cost effective, accessible DR screening option for rural and remote populations.<sup>19,21</sup>

## DISCUSSION

This review has shown that over the past 17 years research studies designed to determine the effectiveness of retinal photography-based DR screening programs in Australia have been highly effective. The introduction of retinal photography-based DR screening programs would dramatically increase participation rates and therefore reduce the incidence of blindness. Retinal photography is highly cost-effective.<sup>22</sup> Establishment of appropriate pathways of care for those requiring treatment and notification for future DR screening cycles would be essential.

The present review identified 14 projects (from 12 publications) undertaken in Australia, which all showed the positive impact of retinal photography in screening for DR. Studies assessing other aspects related to DR screening in Australia have all shown positive results. From the earliest studies undertaken in the mid-1990s until the most recent study published in 2013, a consistent finding has been the identification of patients who had not undergone an

eye examination in the recommended time frame to be screened for DR, demonstrating the effectiveness of retinal photography-based DR screening programs to augment current eye care services. This finding was observed in studies undertaken in urban populations,<sup>6–11</sup> rural and remote communities,<sup>3,7,8,12–14</sup> and regional areas<sup>6,8,15</sup> in Australia. This finding is not surprising and supports the literature internationally that has shown the effectiveness of DR screening programs.<sup>23–26</sup>

There are currently seven funded projects underway in Australia to assess the effectiveness of retinal photography in screening for DR that we are aware of. In addition, during the late 1990s and 2000s substantial funding was provided (in Australia) to assess retinal photography screening for DR as a result of the National Diabetes Strategy and Implementation Plan and the National Framework for Action to Promote Eye Health and Prevent Avoidable Blindness and Vision Loss.<sup>27</sup> For example, funding of AU\$13.8 million over 4 years was allocated in the 2006 Federal Budget for a range of initiatives to promote eye health and strengthen eye health service delivery<sup>27</sup> nationally.

Provision of a DR screening program does not necessarily guarantee that it will be used. However, several countries have well-established DR screening programs that have been highly effective. Iceland was the first country to initiate systematic screening for DR (in 1980).<sup>24,28</sup> The prevalence of blindness within the population with diabetes decreased from 2.4 to 0.5% over the first 14 years of the program. Since 1990, a program has been implemented in Stockholm County (Sweden) for the early diagnosis of DR, which showed over 5 years the average annual incidence of blindness reduced by 47%.<sup>25</sup> Annual diabetes eye screening has been implemented in England and Wales since 2008. As part of the National Health Service Diabetic Eye Screening Program, all individuals aged 12 years and older who are diagnosed with diabetes in primary care are invited to participate in annual screening for DR. In 2011–2012, 81% of people with diagnosed diabetes who were invited to be screened attended.<sup>26</sup> A recent publication by Liew and co-authors has for the first time in almost 5 decades shown that DR/maculopathy is no longer the leading cause of blindness in working age adults in England and Wales, and suggested this may relate to the introduction of nation-wide public health measures.<sup>29</sup> In Ireland, a national DR screening program is just being rolled out.<sup>19</sup> In France, the OPHDIAT network was created in 2004 with the aim of improving screening for DR.<sup>23</sup> In total, 38,596 patients were screened between June 2004 and December 2009. Of these, 14.7% were referred for advanced stages of retinopathy or concomitant eye diseases (1.9%).

Given the repeated success of DR screening programs using retinal photography overseas, the effectiveness of programs in Australia and the

recommendation from the NHMRC around regular eye screening for DR, it seems important that support for sustainable retinal photography-based DR screening programs is examined. The Australian health care system is a hybrid system that is financed by public and private sources that operate in parallel. Public funding for hospitals is provided at a state level, whereas the national health service (Medicare) is run by the Commonwealth Government of Australia and provides funding for medical and primary care and for optometry services within a private practice model. Medicare provides universal health insurance, although many people also have additional private health insurance.

This review has some limitations. Electronic records were only beginning to be put in place during the mid-1990s and so the outcomes of some projects may not have been recorded electronically. Some of the projects used existing services, and may not have reached those most likely to not have undergone screening for DR. However some of the programs trialed mobile clinics and had very good response rates, suggesting that, provided the service is available, people will attend. The studies were inconsistent in reporting key findings, in particular, data on the number identified with DR who went on to receive appropriate after care was sparse (only reported in three of the projects). Future studies focused on whether persons with DR detected at screening, follow referral recommendations to receive care of specialists and improve the control and management of diabetes, would close a major knowledge gap.

This review has shown there have been many pilot and demonstration projects in Australia that confirm the effectiveness of retinal photography-based screening for DR, in both remote and urban settings.

## DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the writing and content of the paper.

The authors have no funding sources to declare.

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