DR Screening In Singapore: Achievements & Future Challenges

Ecosse Lamoureux
Director, Population Research Platform
Singapore Eye Research Institute (SERI)
Background

• About 600,000 of Singaporeans aged 18-69 years have diabetes mellitus (DM). *(MOH Website – 11.3% of Singapore population are diabetics (2011))*

• 30% (180,000) have diabetic retinopathy (DR) and 10% (54,000) have severe or vision-threatening DR

**Diabetic Retinopathy (DR)** - a disorder of the blood vessels in the retina of patients with DM

“1 in 3 diabetic patients has DR; 1 in 10 has vision-threatening DR” *(Cheung, Mitchell, Wong, Lancet 2010)*

Leading cause of vision impairment among adults, and often has no early warning signs.

**Recommended guideline:**
Have eye check at least once a year
Epidemiological Studies on DR in Singapore

Prevalence and Risk Factors for Diabetic Retinopathy in the Singapore Malay Eye Study

Tien Y. W. Wong, MD, PhD,1,2,3 Ning Cheng, MBBS,1 Wun Ting Tay, RSc,7 Jie Jin Wang, MD, PhD,1,4 Tien Y. W. Wong, MD, PhD

Purpose: To describe the prevalence and risk factors of diabetic retinopathy in Asian Malays.

Design: Population-based cross-sectional study.

Participants: Persons with diabetes of Malay ethnicity aged 40 to 80 years in Singapore.

Methods: Diabetic retinopathy was defined as random glucose of 11.1 mmol/L or more, use of diabetic medications, or a physician diagnosis of diabetes. Retinal photographs taken from both eyes were graded for diabetic retinopathy using the modified Airlie House classification system.

Main Outcomes Measures: All diabetic retinopathy, retinopathy grades, macular edema, or vision-threatening retinopathy.

Results: Of the 3081 persons who participated in this study, 757 (23.1%) had diabetes andgradable retinopathy. Persons with diabetes, the overall prevalence of any retinopathy was 85.2% (95% confidence interval CI), 28.2–43.4, the overall prevalence of macular edema was 5.7% (95% CI, 3.2–9.9), and the overall prevalence of vision-threatening retinopathy was 9.0% (95% CI, 5.8–13.8). Compared with men, women had significantly higher proportions with more severe diabetes vs. 0.23% nonproliferative retinopathy, proliferative retinopathy (1.7% vs. 3.9%), and macular edema (1.3% vs. 7.0%).

Racial Differences in the Prevalence of Diabetes but Not Diabetic Retinopathy in a Multi-ethnic Population

Peggy C. P. Chiang,1,2 Ecece I. L. Llamas,3,4 Carol Y. Cheung,1,3 Cherm Sarnarayan,4 Wai Sheng Wong,1 E Shyang Tai,1,5 Jeanette Looe,6 and Tien Y. Wong1,2,7

Purpose: To compare the prevalence and risk factors of diabetes (DM) and diabetic retinopathy (DR) in a multiethnic Asian population of Chinese, Malay, and Indians in Singapore.

Methods: A total of 2019 individuals participated in a population-based, cross-sectional study in Singapore of Chinese (n = 1033), Malays (n = 920), and Indians (n = 920) aged 40 to 95 years, with retinal photographs graded for the Early Treatment Diabetic Retinopathy Study (ETDRS) severity scale. DR was defined as having fasting plasma glucose ≥6.1 mmol/L, retinal vascular occlusion-diagnosed diabetes, and use of a glycosylated hemoglobin (HbA1c) ≥6.5%.

Results: The overall age-standardized prevalence of diabetes was 13.3% (Chinese, 11.9%; Malays, 12.3%; and Indians, 21.0%), p < 0.0001. Among persons with diabetes (n = 240), the overall prevalence of any retinopathy was 85.2% (95% CI, 69.0–96.4) per person, per year increase, higher glomerular filtration rate (124.1 vs. 109.9; 95% CI, 1.01–1.54, per 1% increase), and serum creatinine levels (1.01–1.00 vs. 1.01–1.02, per mg/dL increase) were the independent risk factors of DR in the whole population. Race was not found to be associated with DR (Chinese, 1.39; Malays, 1.00; Indians, 1.00–1.80). The associations of major risk factors with DR were similar among the three ethnic groups.

Conclusions: There was a significant difference in the prevalence of diabetes between Chinese, Malays, and Indians. The main risk factors of DR similar among the three ethnic groups, namely diabetes duration, higher HbA1c, and higher creatinine levels. No significant racial differences were found in the prevalence of DR among persons with diabetes.
### Risk factors Similar in Asians vs Whites, Singapore Malay Eye Study

(Wong TY et al. Ophthalmology 2008)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Any Retinopathy</th>
<th>p</th>
<th>Vision threatening Retinopathy</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, per 10 years</td>
<td>0.73(0.57, 0.93)</td>
<td>0.01</td>
<td>0.61(0.40, 0.94)</td>
<td>0.03</td>
</tr>
<tr>
<td>Diabetes duration, per year</td>
<td>1.07(1.04, 1.09)</td>
<td>&lt;0.001</td>
<td>1.08(1.05, 1.11)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum glucose, per mmol/L</td>
<td>1.05(1.02, 1.09)</td>
<td>0.004</td>
<td>1.10(1.05, 1.17)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HbA1c, per mmol/L</td>
<td>1.21(1.10, 1.33)</td>
<td>&lt;0.001</td>
<td>1.23(1.06, 1.42)</td>
<td>0.007</td>
</tr>
<tr>
<td>Systolic BP, per 10 mmHg</td>
<td>1.17(1.08, 1.28)</td>
<td>&lt;0.001</td>
<td>1.35(1.18, 1.55)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulse pressure, per 10 mmHg</td>
<td>1.34(1.19, 1.51)</td>
<td>&lt;0.001</td>
<td>1.73(1.42, 2.11)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total cholesterol, per mmol/L</td>
<td>0.75(0.63, 0.89)</td>
<td>0.001</td>
<td>1.12(0.88, 1.42)</td>
<td>0.36</td>
</tr>
<tr>
<td>Body mass index, per kg/m²</td>
<td>0.96(0.92, 1.00)</td>
<td>0.08</td>
<td>0.93(0.86, 1.00)</td>
<td>0.04</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>1.57(0.88, 2.81)</td>
<td>0.13</td>
<td>2.29(0.90, 5.83)</td>
<td>0.08</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>1.06(0.48, 2.34)</td>
<td>0.88</td>
<td>3.74(1.24, 11.3)</td>
<td>0.02</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>1.22(0.77, 1.94)</td>
<td>0.40</td>
<td>2.23(1.08, 4.62)</td>
<td>0.03</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>1.48(0.99, 2.21)</td>
<td>0.06</td>
<td>4.45(2.18, 9.07)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Awareness and control of DR Risk Factors in Asia is Poor

Lack of Awareness amongst Community Patients with Diabetes and Diabetic Retinopathy: The Singapore Malay Eye Study

Olivia S Huang,1 2 Wan Ting Tay,1 2 Tan,2 E Shyong Tai,1 2 Chu,2 R, Xie,2 Jie Jin Wang,2 3 Xie,2,3 Seang-Mei Seng,1 2 Tan,2 Xie,1 2 V Swetha E Jegannathan,1 2 Tan,2 Xie,1 2 Myra Sundar,2 3 Tan,2 Xie,1 2 Tian Y Wong,1 2 Tan,2 Xie,1 2

Abstract

Introduction: We assessed awareness of diabetes and diabetic retinopathy in a Singaporean Malay population. We hypothesised that poor awareness is associated with poorer control of diabetes retinopathy risk factors (glycemic and blood pressure levels) and suboptimal treatment with laser therapy. Methods and Methods: A population-based survey of 3280 (78.7% response rate) persons among Singaporean Malays aged between 40 and 80 years old. Diabetes was defined in persons with random glucose ≥11.1 mmol/L, use of diabetics medication, or a previous physician diagnosis. Diabetic retinopathy was graded from retinal photographs following the modified Airlie House classification. Patient awareness was assessed via structured interviews. Glycated haemoglobin A1c was measured from venous blood. Results: Of the 3280 study participants, 768 had diabetes, of whom 13.2% (n = 101) were unaware of their diabetes status. Participants unaware of their diabetes status had significantly higher mean glycated haemoglobin (9.7 vs 8.2%, P = 0.001), systolic blood pressure (160 vs 153.7 mmHg, P = 0.01) and diastolic blood pressure (83.5 vs 81.5 mmHg, P = 0.001), compared to participants who were aware. Of the 727 (35.4%) participants detected to have diabetic retinopathy, 93.4% (n = 227) were unaware of having retinopathy. Of the 77 with vision-threatening retinopathy, laser treatment had been performed in only 55.6% of those unaware of having retinopathy. Conclusions: In a sample of Malays with diabetes, high levels of unawareness of their disease. Unawareness was associated with poorer control of diabetes retinopathy risk factors. Only half of persons who were unaware that they had vision-threatening diabetic retinopathy had received laser treatment. These data highlight room for improvement in diabetic retinopathy prevention through better patient education and screening.

Ann Acad Med Singapore 2009;38:xxx

Glycemic and Blood Pressure Control in an Asian Malay Population With Diabetes and Diabetic Retinopathy

Olivia S. Huang, BSc (Mod); Ecosse L Lamoareux, PhD; Wan Ting Tay, BSc; E Shyong Tai, MRCP; Jie Jin Wang, PhD; Tian Y. Wong, MD, PhD

Objective: To examine the prevalence of and factors associated with suboptimal glycemic and blood pressure (BP) control in a Malay population with diabetes mellitus in Singapore.

Methods: The Singapore Malay Eye Study was a population-based survey of 3280 Malay individuals (78.7% response rate) aged 40 to 80 years. Diabetes was defined as a nonfasting glucose level of 200 mg/dL or greater, use of diabetics medication, or physician diagnosis. Diabetic retinopathy (DR) was graded from retinal photographs using the modified Airlie House classification. Optimal control was defined as a hemoglobin A1c level of less than 7% and BP of 130/80 mm Hg or lower.

Results: In participants with diabetes (n = 768), only 26.9% had optimal glycemic and 13.4% optimal BP control, respectively. In those with DR (n = 272), rates of optimal glycemic and BP control were even lower (17.4% and 10.3%, respectively). After adjusting for age, sex, socioeconomic status, and other factors, compared with participants with optimal glycemic control, those with suboptimal control were younger (P = .005), more likely to be unaware of their diabetes status (P < .001), and taking medication for diabetes (P < .001) and had higher levels of total cholesterol (P = .009) and DR (P < .001). After adjusting for similar risk factors, compared with participants with optimal BP control, those with suboptimal BP control were older (P = .000) and more likely to have higher total cholesterol levels (P < .001), BMI (P = .04), and DR (P = .02).

Conclusions: In this Asian Malay population with diabetes, more than three-quarters had poor glycemic and BP control. Strategies to improve awareness and implementation evidence-based guidelines are needed to reduce the effect and burden of diabetic complications in Asia.

2004 MOH Management of Diabetic Retinopathy Guidelines recommend the establishment of a national-level DR screening programme.
Current DR Screening Models in Singapore

- Ad-hoc DR screening nationally
- Mostly conducted within the primary care settings in the government (polyclinics) and private sectors (family physicians or GPs)
- Retinal photos are assessed by family physicians in the polyclinic (who have undergone some training on DR grading) and are accredited every 2 years
- Patients are referred for ophthalmic management at tertiary eye centers
- Turnaround time for family physicians to grade retinal photos: **2 to 4 weeks**
Limitations of Current Polyclinic Model

- **Cost-ineffective** as physicians are made to assess DR when this can be performed by trained technicians or optometrists
- **Lack of time** for physicians to grade images, resulting in delays in detection and referral
- **Inconsistencies in the grading outcomes** with no standardized protocol and quality assurance
- **Evidence of high over-referral rate** to tertiary eye care (i.e. only 38% of those referred are true DR positive)
- **Not comprehensive** as patients with diabetes seen in private sector are not routinely captured
- **Delay in diagnosis and referral** of patients with DR
Singapore Integrated Diabetic Retinopathy Programme (SiDRP)

• To implement a **national screening program** for diabetic retinopathy (DR) based on tele-medicine and centralized reading centres
• Key outcomes: “Better, Faster, Cheaper”
1. IMAGE CAPTURE SITES

- Polyclinics
- Hospitals
- Optometrist
- General Practitioners
- Mobile Vehicles

2. TRANSMIT TO READING CENTRE

Images are transmitted to the imaging laboratory via a secured web-based platform.

3. IMAGE GRADING

Images are graded by a centralised team of trained and accredited technicians. Reports are transmitted back **within 1 hour**.

4. REPORT TO CLINICIANS

Referrals are made by the doctors during the same visit.
SiDRP Locations
SiDRP Concepts

1. ‘Better’
   - National coverage of all 600,000 persons with diabetes
   - In-built quality assurance processes
   - Improved accurate (e.g., reduce false negative and positive)
   - Allows technological improvements (e.g., automation, OCT)

2. ‘Faster’
   - “Real-time” feedback and referral: “1-hour” turn-around

3. ‘Cheaper’
   - Replace primary care physicians with technicians/ optometrists reading DR photos
   - Allow primary care physicians to optimize time for clinical care
   - Reduction in tertiary eye care referrals → savings in cost, time and resources
## SIDRP Journey

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td><strong>July 2010:</strong> Outram Polyclinic Goes Live!</td>
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<tr>
<td></td>
<td><strong>August 2010:</strong> Bukit Merah Polyclinic Goes Live!</td>
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<tr>
<td>2011</td>
<td><strong>January 2011:</strong> Pasir Ris Polyclinic Goes Live!</td>
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<tr>
<td>2012</td>
<td><strong>January 2012:</strong> Diabetic Society of Singapore</td>
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<td><strong>September 2012:</strong> Novartis</td>
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<td><strong>November 2012:</strong> SATA Commhealth</td>
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<tr>
<td>2013</td>
<td><strong>April 2013:</strong> Frontier Family Medical Clinic</td>
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<tr>
<td></td>
<td><strong>March – June 2013:</strong> Paris Miki Roadshow</td>
</tr>
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<td></td>
<td><strong>June 2013:</strong> Singapore General Hospital (Diabetes Centre)</td>
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<td></td>
<td><strong>Future Expansion in 2014:</strong></td>
</tr>
<tr>
<td></td>
<td>• National University Health System (NUHS)</td>
</tr>
<tr>
<td></td>
<td>• Changi General Hospital</td>
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<tr>
<td></td>
<td>• Community Health Centre (Tampines)</td>
</tr>
</tbody>
</table>

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*SIDRP Journey*
## SiDRP KPIs

<table>
<thead>
<tr>
<th>Desired Outcome(s)</th>
<th>Proposed yearly Target(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved grading results and quality assurance</td>
<td>Accuracy in detection of DR for 85% of cases per year</td>
</tr>
<tr>
<td>Faster Turn-around time to enable immediate diagnosis</td>
<td>95% of cases achieved 1-hr turnaround time</td>
</tr>
<tr>
<td>Saving in Manpower cost (Reading Centres)</td>
<td>Cost saving of $550,000/year from cost differential of 10 FP vs 10 Graders</td>
</tr>
<tr>
<td>Patient Safety</td>
<td>Keep risk of Adverse Events below 0.1% risk</td>
</tr>
<tr>
<td>Patient Satisfaction Survey</td>
<td>Achieve 80% of patients satisfied with the DR screening services served by reading centres</td>
</tr>
</tbody>
</table>
SiDRP
Patient Report

**Recommended Action:**
The family physician at the polyclinic would interpret the report, provide the relevant diagnosis, counsel the patient and refer accordingly.
SiDRP Outcomes
SIDRP- Screening and Referral

No. of patients screened in Polyclinics

- 18,837 (72%)
- 5,432 (21%)
- 7%

n = 26,163

DRP Charges (2013):
- SERI: Bukit Merah, Outram & Pasir Ris Polyclinics
  - SHSP & NHGP: $8.50 - $8.80 (Singapore Citizens)
  - Tertiary Eye Centre (e.g. SNEC): $20 (Subsidized) $40 (Private)

Annual Screening
Referral to Eye Centre
Re-screen 6 months
Reasons for referral

Year 2013

- Diabetic Retinopathy: 20.8%
- Macular Edema: 7.3%
- AMD: 1.5%
- Glaucoma: 9%
- Cataract: 14.3%
- Others: 34.3%
- Ungradeable: 6.7%
Tertiary Referral and Uptake @ SNEC

Tertiary Eye Care Institutions
N = 1,578 (20.7%)

Other Tertiary Eye Institutions
N = 398 (25.2%)

Refer to SNEC
N = 1,180 (74.8%)

Subjects that case notes cannot be retrieved/Did not attend referrals
N = 368 (32%)

Attended referrals
N = 812 (68%)

- DR
N = 55
(14.9%)

- DME
N = 76
(20.7%)

- Cataract
N = 77
(20.9%)

- AMD
N = 23
(6.2%)

- Glaucoma
N = 26
(7.1%)

- Others
N = 89
(24.2%)

- Ungradable
N = 22
(6.0%)
Attended referrals
N = 812

Comparison between referral time recommended by graders and actual referral date
N = 98

Secured appointments within recommended time
N = 30 (30%)

Did not secure appointments within time recommended SIDRP period N = 68 (70%)

Urgent/Immediate referrals
N = 13 (43%)

1-6 months referrals
N = 17

Proliferative DR
N = 1

DME
N = 5

Glaucoma suspect
N = 1

AMD with poor vision
N = 1

BRVO
N = 1

Haemorrhage at macular
N = 1

Macular pseudohole
N = 1

Poor vision
N = 2
## Accuracy for Any DR (N=747 eyes)

### FP/Grader vs. Gold standard (Ophthalmologist using fundus images)

<table>
<thead>
<tr>
<th>Diagnostic tests</th>
<th>Diagnostic Tests, (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>FP vs. Ophthalmologist</strong></td>
</tr>
<tr>
<td>Accuracy</td>
<td>84.3% (81.6, 86.7)</td>
</tr>
<tr>
<td></td>
<td><strong>Grader vs. Ophthalmologist</strong></td>
</tr>
<tr>
<td></td>
<td>90.1% (87.7, 92.1)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>44.7% (36.5, 53.2)</td>
</tr>
<tr>
<td></td>
<td>69.8% (61.3, 77.2)</td>
</tr>
<tr>
<td>Specificity</td>
<td>92.4% (90.1, 94.2)</td>
</tr>
<tr>
<td></td>
<td>94.4% (92.3, 96.1)</td>
</tr>
<tr>
<td>+ve predictive value</td>
<td>54.6% (45.2, 63.7)</td>
</tr>
<tr>
<td></td>
<td>73.3% (64.8, 80.4)</td>
</tr>
<tr>
<td>-ve predictive value</td>
<td>89.1% (86.5, 91.3)</td>
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<tr>
<td></td>
<td>93.5% (91.2, 95.2)</td>
</tr>
<tr>
<td>+ve likelihood ratio</td>
<td>5.90 (4.25, 8.20)</td>
</tr>
<tr>
<td></td>
<td>12.66 (8.87, 18.07)</td>
</tr>
<tr>
<td>-ve likelihood ratio</td>
<td>0.60 (0.51, 0.70)</td>
</tr>
<tr>
<td></td>
<td>0.32 (0.25, 0.42)</td>
</tr>
<tr>
<td>AUC*</td>
<td>0.686 (0.642, 0.729)</td>
</tr>
<tr>
<td></td>
<td>0.822 (0.780, 0.863)</td>
</tr>
</tbody>
</table>

*AUC = area under receiver operating characteristic curve
### Conditional Sensitivity, Specificity, PPV, NPV & Accuracy

<table>
<thead>
<tr>
<th>Condition</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td><strong>DR</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Graders</td>
<td>98.3%</td>
<td>58.7%</td>
<td>0.612</td>
<td>0.925</td>
<td>0.727</td>
</tr>
<tr>
<td>Ophthalmologist</td>
<td>112</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graders</td>
<td>71</td>
<td>98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DME</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Graders</td>
<td>87.1%</td>
<td>63%</td>
<td>0.221</td>
<td>0.975</td>
<td>0.656</td>
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<tr>
<td>Ophthalmologist</td>
<td>27</td>
<td>4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Graders</td>
<td>95</td>
<td>162</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AMD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graders</td>
<td>43.6%</td>
<td>94.3%</td>
<td>0.548</td>
<td>0.913</td>
<td>0.906</td>
</tr>
<tr>
<td>Ophthalmologist</td>
<td>17</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graders</td>
<td>14</td>
<td>232</td>
<td></td>
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<tr>
<td><strong>Glaucoma Suspect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graders</td>
<td>73.2%</td>
<td>96.3%</td>
<td>0.833</td>
<td>0.917</td>
<td>0.874</td>
</tr>
<tr>
<td>Ophthalmologist</td>
<td>52</td>
<td>19</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Graders</td>
<td>8</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Mild NPDR**: more than 5 but less than 10 HMAs, or 1-2 blot hemorrhage; **Moderate NPDR**: ≥ 3 blot hemorrhages, or ≥ 10 HMAs, or any flame-shaped hemorrhage(s), or venous beading in 1 quadrant only; **Severe NPDR**: Any IRMA(s), or venous beading in 2 or more quadrant, or 4 quadrants of dot and blot hemorrhage(s); **PDR**: Any NVD(s)/NVE(s), or vitreous hemorrhage, or pre-retinal hemorrhage(s)
- **DME**: Presence of microaneurysms or hard exudates within 2DD of macular center
- **AMD**: Drusens ≥ 125 microns or pigmentary abnormalities within 2DD of the macular center, with VA 6/18 or worst (no clear referral criteria to refer AMD)
- **Glaucoma Suspect**: Cup disc ratio ≥ 0.65 in either eye

**Definition (Based on 2012 referral criteria)**
## Inter-rater Agreement between SORC Trained Grader and Ophthalmologist on Severity of DR

<table>
<thead>
<tr>
<th>Trained Grader</th>
<th>Mild DR</th>
<th>Moderate DR</th>
<th>Severe DR</th>
<th>PDR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild DR</td>
<td>44</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>52 (46.4%)</td>
</tr>
<tr>
<td>Moderate DR</td>
<td>21</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>36 (32.1%)</td>
</tr>
<tr>
<td>Severe DR</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>0</td>
<td>18 (16.1%)</td>
</tr>
<tr>
<td>PDR</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>6 (5.4%)</td>
</tr>
</tbody>
</table>

| Total          | 71 (63.4%) | 23 (20.5%) | 13 (11.6%) | 5 (4.5%) | 112 |

Weighted Kappa = **0.49** (0.34 to 0.64)
Patient Satisfaction Survey

“When compared with the previous eye screening service, do you think that it is more convenient for you to have your DR eye screening under this programme?”

92.8% Agree
7.2% Disagree

N = 239
Family Physician Survey

“Do you think you are providing a better service with the new programme?”

- Pasir Ris: 80.00% Yes, 20.00% Not Sure / Don't Know
- Bukit Merah: 100.00% Yes
- Outram: 100.00% Yes

Yes
No
Not Sure / Don't Know
A Cost Effectiveness Analysis of SiDRP

• Compare 3 alternative strategies:

  1. No DR screening
  2. DR screening by family physicians
  3. DR screening by SiDRP
A Five-Health-State Markov Model

1. No DR
2. Mild DR
3. Moderate/Severe DR
4. Stabilized DR
5. Blindness
Model Inputs And Assumptions

- A cohort of 1,000 people with diabetes
- Time horizon: 40 years
- Utilities and transition probabilities taken from literature
- Government’s perspective
- Prevalence and costs of DR screening and DR treatment specific to Singapore
- Cost of a laser treatment: $2,000
- Cost of one hospital visit: $200
- Unsubsidized cost of one-time DR screening: $8 (SiDRP) and $25 (family physicians)
Model Assumptions

• DR hospital diagnosis is always correct
• Under the no screening regime, only half of severe DR patients get diagnosed and treated ultimately; the remaining half does not
• Patients with mild DR are referred to hospitals by family physicians. For SiDRP, patients return for re-photography in 6 months to monitor for progression
• All moderate/severe DR patient receive a laser treatment; this treatment mostly likely to stabilize the patient’s DR state; there is no repeated laser treatment
## Cost Effectiveness: SiDRP Versus Family Physicians

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Costs ($) Per Patient</th>
<th>Incremental Costs ($)</th>
<th>Incremental QALYs Per Patient</th>
<th>Incremental QALYs</th>
<th>Incremental Cost Effectiveness Ratio (ICER)</th>
<th>Number of Blindness Cases Occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiDRP</td>
<td>$4,060</td>
<td>-</td>
<td>31.21</td>
<td>-</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>Family Physician Grading</td>
<td>$4,160</td>
<td>$100</td>
<td>31.21</td>
<td>0</td>
<td>Dominated</td>
<td>17</td>
</tr>
</tbody>
</table>
# Cost Effectiveness Result: SiDRP Versus No Screening

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Costs ($) Per Patient</th>
<th>Incremental Costs ($)</th>
<th>QALYs Per Patient</th>
<th>Incremental QALYs</th>
<th>Incremental Cost Effectiveness Ratio (ICER)</th>
<th>Number of Blindness Cases Occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>No DR Screening</td>
<td>$1,482</td>
<td>-</td>
<td>30.76</td>
<td>-</td>
<td></td>
<td>82</td>
</tr>
<tr>
<td>SiDRP</td>
<td>$4,060</td>
<td>$2,580</td>
<td>31.21</td>
<td>0.45</td>
<td>$5,670</td>
<td>17</td>
</tr>
</tbody>
</table>
Future Challenges

- To increase our DR screening coverage (more polyclinics, GPs, better access to technology, etc.)
- Streamline our grading protocol, referral criteria, internal audit, quality control, etc... to optimize our grading performance and alignment with screening models elsewhere
- Investigate the effectiveness of including OCT to screen for maculopathy in our screening model
- Determine the cost effectiveness of fundus and/or OCT from both societal and patient perspectives
- Investigate predictive models and interventions to improve adherence to referral uptake and rescreen
Conclusion

• **Better healthcare** for patients with diabetes

• Reduce overall *cost and healthcare burden*

• Better *overall patient experience*

• Ability to *tap into technology*

• A number of *challenges* remain though