The Singapore Integrated Diabetic Retinopathy Program: Achievements and Challenges

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Global projections for diabetes

Increase of 54%

Diabetes - Asian Epidemic
Increasing prevalence of diabetes in Asia

Socio-economic development
...diet, lifestyle, physical activity, obesity...

Adults aged 20-79
Age-adjusted to world population

Socio-economic development and urbanization in India…
Singapore has one of the highest rates of diabetes globally

- Approximately 13% of Singaporeans between 20-79 years have diabetes (DM; IDF Diabetes Atlas 2015)
  - Second highest proportion among developed nations
  - Prevalence among three major ethnicities are estimated at 11.5% in Chinese, 17.1% in Malays, 21.6% in Indians ≥ 40 years (Chiang et al, 2011)

- DM prevalence and burden estimated to increase in coming decades due to increasing affluence and longer lifespan
  - Projected to increase to ~US$2.0 billion by 2050
Visual complications from DM is a leading cause of visual impairment

- Diabetic retinopathy (DR) and macular edema (DME) are the most common visual microvascular complications of DM
- Leading causes of visual impairment (VI) in working-aged adults (Cheung, 2010)
- In Singapore, almost 80% of those with DR were unaware they had the condition (Huang et al, 2015)
Impact of DR & DME: Patient's Perspectives

Qualitative work by our group in Australia has highlighted the diverse burden of DR/DME on QoL (Fenwick et al. 2012)

Patient focus group, transcript analysis:

“The effects on me were devastating. I had to leave my job, which was teaching, and my hobby was stamp collecting and I used to write… All my interests, just overnight I was unable to do them. But probably the worst problem for me has been psychological…I had a fair bit to offer my wife, but when I lost my vision I suddenly felt that I had nothing to offer her. So I told her to go so that she didn’t have to put up with a…fat old man who was blind.”

Emotional; Economic; Activity limitation; Convenience; Social
Impact of DR & DME on QoL

- DR has a considerable impact on patients’ visual functioning and quality of life (QoL) \((\text{Lamoureux et al. 2007})\)

- Greatest impact at the vision-threatening stages
  - Loss of 3 lines on an eye chart resulted in worse mental health, more role difficulties, and greater difficulty driving \((\text{Hirai et al, 2010})\)

- QoL impact is worse when the disease is severe in both eyes compared to just one eye
  - More problems with daily activities, dependency and mental health \((\text{Mazhar et al, 2010})\)
Impact of DR & DME in Singapore

Impact of Diabetic Retinopathy on Vision-Specific Function

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Objective: To assess the influence of the spectrum of diabetic retinopathy (DR) on vision-specific function in an Asian population.

Design: Population-based cross-sectional study.

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

Methods: The Singapore Malay Eye Study was a population-based, cross-sectional study of 3280 Asian Malays (78.7% response rate). Five end points were considered: (1) any DR, (2) macular edema (ME), (3) clinically significant macular edema (CSME), (4) vision-threatening DR (VTDR), and (5) DR severity levels ranging from none to proliferative diabetic retinopathy (PDR). Vision function was assessed using the Vision-Specific Functioning Scale validated using Rasch analysis.

Main Outcome Measures: Vision-specific functioning score.

• Persons with vision-threatening DR were 6 times more likely to report lower participation in daily living activities.

• Persons with PDR were 12 times more likely to report lower participation in daily living activities.
Many epidemiological risk factor studies on DR, with increasing data from Asia...

Studies show that “classic” risk factors for DR are similar in Asians vs Western populations....
### Diabetic Retinopathy

<table>
<thead>
<tr>
<th></th>
<th>Vision-threatening Retinopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, per 10 years</td>
<td>0.73(0.57, 0.93)</td>
</tr>
<tr>
<td>Diabetes duration, per year</td>
<td>1.07(1.04, 1.09)</td>
</tr>
<tr>
<td>Serum glucose, per mmol/L</td>
<td>1.05(1.02, 1.09)</td>
</tr>
<tr>
<td>HbA1c, per mmol/L</td>
<td>1.21(1.10, 1.33)</td>
</tr>
<tr>
<td>Systolic BP, per 10 mmHg</td>
<td>1.17(1.08, 1.28)</td>
</tr>
<tr>
<td>Pulse pressure, per 10 mmHg</td>
<td>1.34(1.19, 1.51)</td>
</tr>
<tr>
<td>Total cholesterol, per mmol/L</td>
<td>0.75(0.63, 0.89)</td>
</tr>
<tr>
<td>Body mass index, per kg/m²</td>
<td>0.96(0.92, 1.00)</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>1.57(0.88, 2.81)</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>1.06(0.48, 2.34)</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>1.22(0.77, 1.94)</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>1.48(0.99, 2.21)</td>
</tr>
</tbody>
</table>

*Adjusted for age, gender, metabolic risk factors (HbA1c, duration of diabetes, systolic blood pressure and BMI) and socio-economic factors (income, housing and education)
...in urban Beijing, China...(Xu et al. 2012)

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per year)</td>
<td>&lt;0.001</td>
<td>0.97</td>
<td>0.95–0.98</td>
</tr>
<tr>
<td>Duration of diabetes</td>
<td>&lt;0.000</td>
<td>1.10</td>
<td>1.08–1.12</td>
</tr>
<tr>
<td>(per year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycosylated hemoglobin</td>
<td>&lt;0.000</td>
<td>1.23</td>
<td>1.14–1.33</td>
</tr>
<tr>
<td>(per 1 mmol/L)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>0.004</td>
<td>1.01</td>
<td>1.01–1.02</td>
</tr>
<tr>
<td>(mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.002</td>
<td>0.95</td>
<td>0.92–0.98</td>
</tr>
<tr>
<td>(kg/m²)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Blood urea nitrogen</td>
<td>0.02</td>
<td>1.01</td>
<td>1.00–1.01</td>
</tr>
<tr>
<td>(mmol/L)</td>
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in rural China..(Wang FH et al. 2011)

<table>
<thead>
<tr>
<th>Diabetic Retinopathy</th>
<th>Odds Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Diabetes‡</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.98 (0.96-1.01)</td>
<td>0.23</td>
</tr>
<tr>
<td>Duration of diabetes, per 5 years</td>
<td>3.07 (1.94-4.85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fasting plasma glucose, per mmol/l</td>
<td>1.17 (1.08-1.27)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Systolic blood pressure, per 10 mmHg</td>
<td>1.22 (1.08-1.37)</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Newly diagnosed Diabetes‡</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.00 (0.97-1.03)</td>
<td>0.95</td>
</tr>
<tr>
<td>Fasting plasma glucose, per mmol/l</td>
<td>1.17 (1.05-1.29)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Systolic blood pressure, per 10 mmHg</td>
<td>1.10 (0.96-1.26)</td>
<td>0.156</td>
</tr>
</tbody>
</table>

† Odds ratio adjusted for age, gender, duration of diabetes, fasting plasma glucose (FPG), systolic blood pressure (SBP), diastolic blood pressure (DBP), low density lipoprotein (LDL), waist hip ratio (WHR) and Ankle-brachial index (ABI) in logistic regression models using stepwise procedures
‡ adjusted for age, gender, FPG, SBP, DBP, LDL, WHR and ABI in logistic regression models using stepwise procedures

...strategies should be focused on tackling **classic risk factors for diabetes**
From Epidemiology to Screening

Primary Prevention
- Systemic risk factor control

Secondary Prevention
- Systemic risk factor control
- Screening of DR

Tertiary Prevention
- Ocular Treatment
- Risk Stratification

Diabetes
N=350m

Mild DR
N=120m

DME
N=20m

Vision Loss
DR screening works!

5-year average annual incidence rate of reports of blindness in diabetic patients (Sweden)

Screening programme for all DM patients implemented 1989-1990

47% reduction in reports of diabetes-related blindness
...but few national DR screening programs

A national screening programme for diabetic retinopathy

Needs to learn the lessons of existing screening programmes

Retinopathy is the biggest single cause of blindness in the United Kingdom. Laser coagulation of high risk lesions detected by screening can significantly reduce the likelihood of blindness and deteriorating vision. Screening for diabetic retinopathy has been available in some areas of the United Kingdom since the late 1980s, but access is uneven, screening techniques of differing effectiveness have been used, quality assurance may not be an integral part, and the resources available are variable. A national screening programme has now been recommended, but several organisational issues need to be tackled if this programme is not to repeat the problems incurred by earlier national screening programmes.

In 1999 the UK National Screening Committee asked the British Diabetic Association (now Diabetes UK) to convene an advisory panel to produce a model for a cost effective national screening programme. The panel’s recommendations are now published on the national screening committee’s website (www.diabetic-retinopathy-screening.nhs.uk/index.html). The preferred method for screening is digital retinal photography. This technology has secondary advantages of easy storage and retrieval of images, which facilitates quality assurance, training, and patient education. However, a baseline assessment of the current position in one English health region has identified some of the issues to be addressed before a comprehensive risk reduction programme can be introduced.

The South West region of England has a population of around 4.9 million. Its eight health districts vary in size from 0.5 to one million people. Two districts currently screen for retinopathy using retinal photography, one of them using digital images. Both screen most patients in a general practice setting. Two more districts have partial screening programmes, one by a hospital based optical

| Number of people identified with diabetes in England (end of year) | 2,587,000 (+4.9% on 2010-11) |
| Number of people offered screening | 2,362,000 (+4.7% on 2010-11) |
| Number of people excluded from screening | 248,000 (+9.9% on 2010-11) |
| Number of people screened | 1,911,000 (+6.8% on 2010-11) |
| Coverage (proportion of people identified with diabetes who were screened) | 73.9% |
| Uptake (proportion of people offered screening who were screened) | 80.9% |
...developing a national DR screening program takes years...

2004 Singapore Ministry of Health “Diabetic Retinopathy” Guidelines recommend the establishment of a national-level DR screening programme
Previous 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 DR Program (SiDRP)

• To design and implement a **national screening program** for DR based on a tele-medicine platform and centralized labs ("reading centres")

• Key outcomes: “Better, Faster, Cheaper”
SiDRP Concepts

1. ‘Better’
   - National coverage of all 440,000 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
Model for SiDRP

Patients and primary care physicians receive feedback within a day (1-24 hrs) and referred for eye specialists on same day (e.g., SNEC, TTSH).

Primary Care Clinics, equipped with retinal cameras (N=18, covering 200K DM patients)
Reading Centre provides the recommended action.

Physicians would then interpret the results and provide the relevant diagnosis to the patient and manage/refer accordingly.
SIDRP- Screening and Referral for 2016

As of 3rd March 2017

No. of patients screened in Polyclinics

<table>
<thead>
<tr>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>51,729</td>
<td>70%</td>
</tr>
<tr>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>19,952</td>
<td>27%</td>
</tr>
</tbody>
</table>

n = 73,898

DRP Charges (2015):
SERI: Bukit Merah, Outram, Geylang, Marine Parade & Pasir Ris Polyclinics
SHSP & NHGP: $8.50 - $9.00 (Singapore Citizens)
# Key Outcomes

<table>
<thead>
<tr>
<th>Desired Outcome(s)</th>
<th>Outcome Indicator(s)</th>
<th>Proposed yearly Targets (2014) – SERI</th>
<th>Proposed yearly Targets (2014) – NHGEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>More accurate grading results and quality assurance</td>
<td>(i) Accuracy of pick-up of DR (sensitivity)</td>
<td>85% of cases per year</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td>(ii) Accuracy of pick-up of non-DR (specificity)</td>
<td>95% of cases per year</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td>(iii) Reduction of tertiary eye care referral (false positive)</td>
<td>Reduce referral of 15% DR patients each year</td>
<td>Same</td>
</tr>
<tr>
<td>Faster Turn-around time to enable immediate diagnosis</td>
<td>1-hr turnaround time (SERI)</td>
<td>80% of cases achieving 1-hr turnaround time</td>
<td>80% of cases receiving an appointment notification at the end of the day</td>
</tr>
<tr>
<td></td>
<td>Appointment notification at the end of the day (NHGEI)</td>
<td>80% of cases receiving an appointment notification at the end of the day</td>
<td></td>
</tr>
<tr>
<td>Saving in Manpower cost (Reading Centres)</td>
<td>DR images review by trained graders at RCs instead of by polyclinics doctors.</td>
<td>Cost savings of $330,000 per year for 9 SH polyclinics</td>
<td>Cost savings of $325,000 per year for 9 NHG polyclinics</td>
</tr>
<tr>
<td>Patient Safety Adverse Events cause by screening related problems (Glaucoma Angle Closure Rate)</td>
<td>Number of Adverse Events</td>
<td>Keep risk of Adverse Events below 0.1% risk</td>
<td>Same</td>
</tr>
<tr>
<td>Patient Satisfaction Survey</td>
<td>Percentage of patient satisfaction</td>
<td>Achieve 90% of patients satisfied with the DR screening services served by reading centres</td>
<td>Same</td>
</tr>
</tbody>
</table>
How satisfied were you with the current DR eye-screening service?

**SHP**
- Very Satisfied: 57%
- Satisfied: 38%
- Somehow Satisfied: 4%
- Somehow Dissatisfied: 3%

**NHG**
- Very Satisfied: 47%
- Satisfied: 50%
- Somehow Satisfied: 3%
- Somehow Dissatisfied: 3%
What is your preferred method of receiving your DR eye screening results if abnormal?

- Wait at the polyclinic to receive my results and see the polyclinic doctor (90%)
- Free to leave upon completion of the eye screening and be informed of my results within the same day by phone (7%)
- Wait for my next consultation to receive my results (2%)
If you prefer to wait for results at the polyclinic, what is the longest time you are willing to wait?

**SHP**
- 57%: Within 1 hour
- 23%: 1-2 hours
- 18%: More than 2 hours
- 2%: No opinion

**NHG**
- 65%: Within 1 hour
- 28%: 1-2 hours
- 7%: No opinion
Would you recommend this service to your friends and family?

**SHP**
- Yes: 82%
- No: 13%
- No Opinion: 5%

**NHG**
- Yes: 87%
- No: 13%
Results indicated that SiDRP generates a cost savings of $173 per patient ($144 from the health system perspective) relative to the FP model while generating equal QALYs.

Extrapolating these results to the current volume of Singaporeans with diabetes represents a significant cost savings of approximately S$30 million over a patient’s lifetime.
Future Challenges

• To increase our DR screening coverage (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
Future Challenges

• Personalize screening frequency.
• Improve adherence to primary re-referrals including foot and kidney screenings.
• Improve adherence to tertiary referrals.
• Automated screening.
• Closely audit the clinical management and outcomes of those with DM with/out early complications.
Conclusion

• Compared to previous DR screening models, SiDRP is:
  – Better
  – Faster
  – Cheaper

• Several challenges to optimize the model to show a significant reduction in diabetes-related vision loss and blindness.
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