The Singapore Integrated Diabetic Retinopathy Program: Achievements and Challenges

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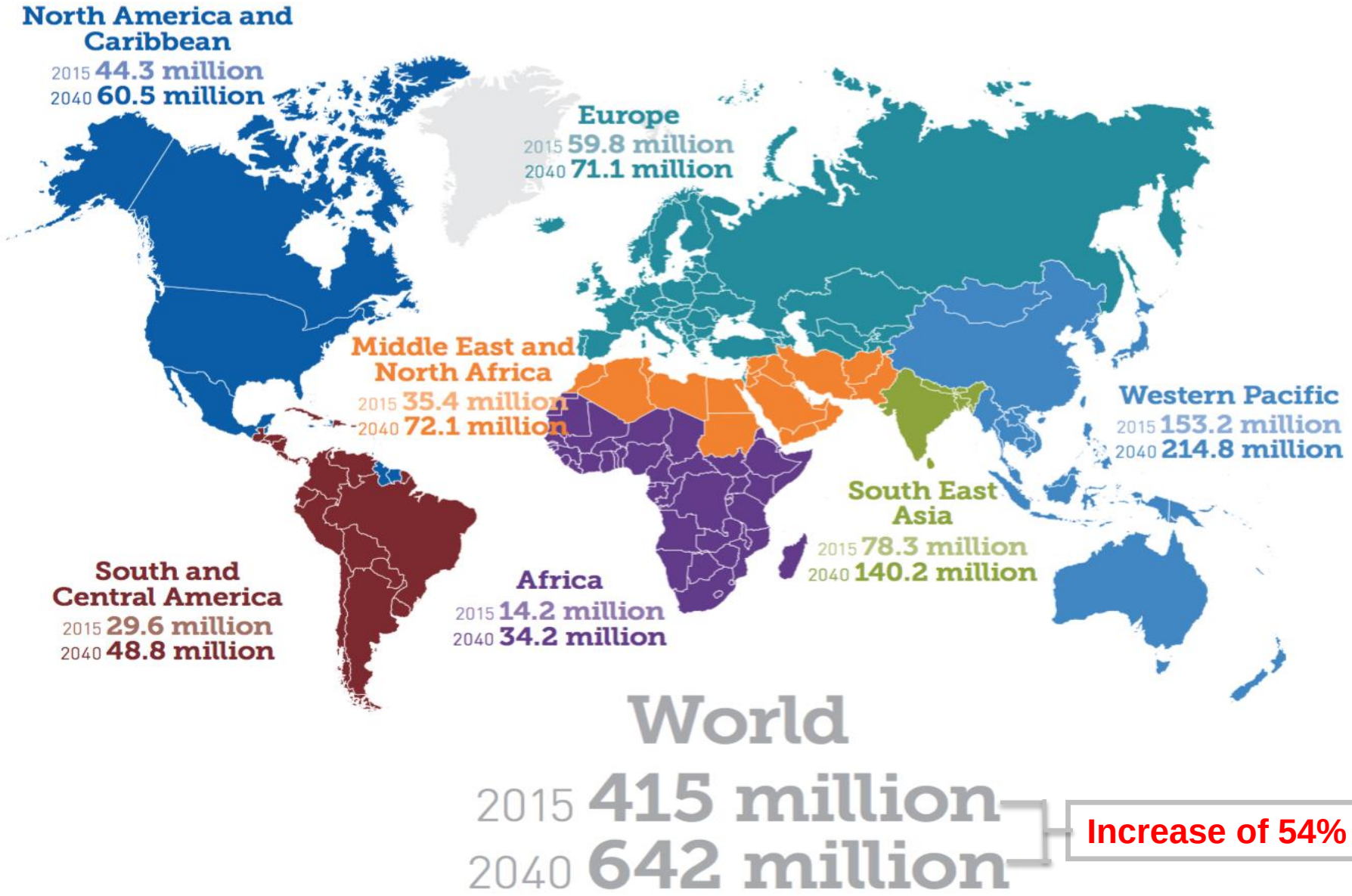
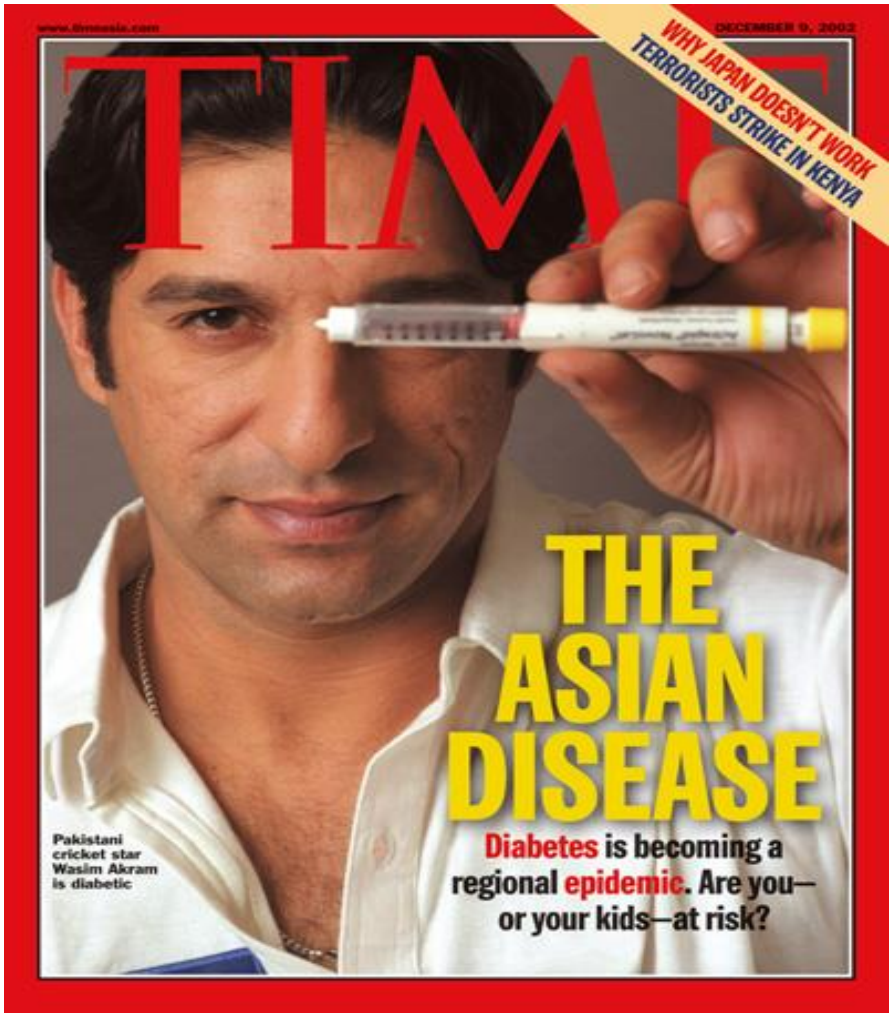
Global projections for diabetes



International Diabetes Federation. Diabetes Atlas. www.idf.org. 2015

Diabetes - Asian Epidemic



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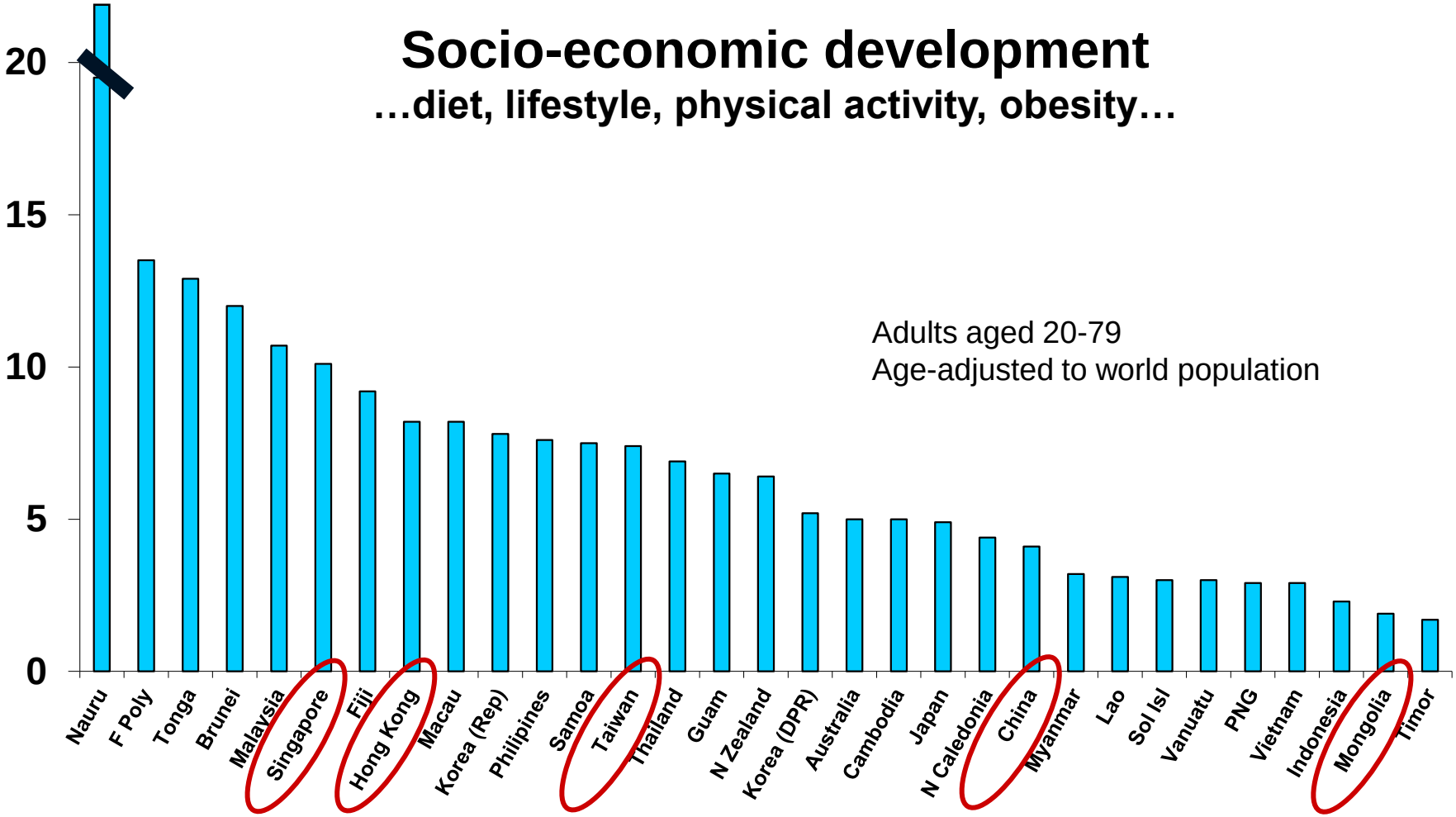
Increasing prevalence of diabetes in Asia



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Sicree, Shaw, Zimmet. *Diabetes Atlas.* IDF www.idf.org. 2006


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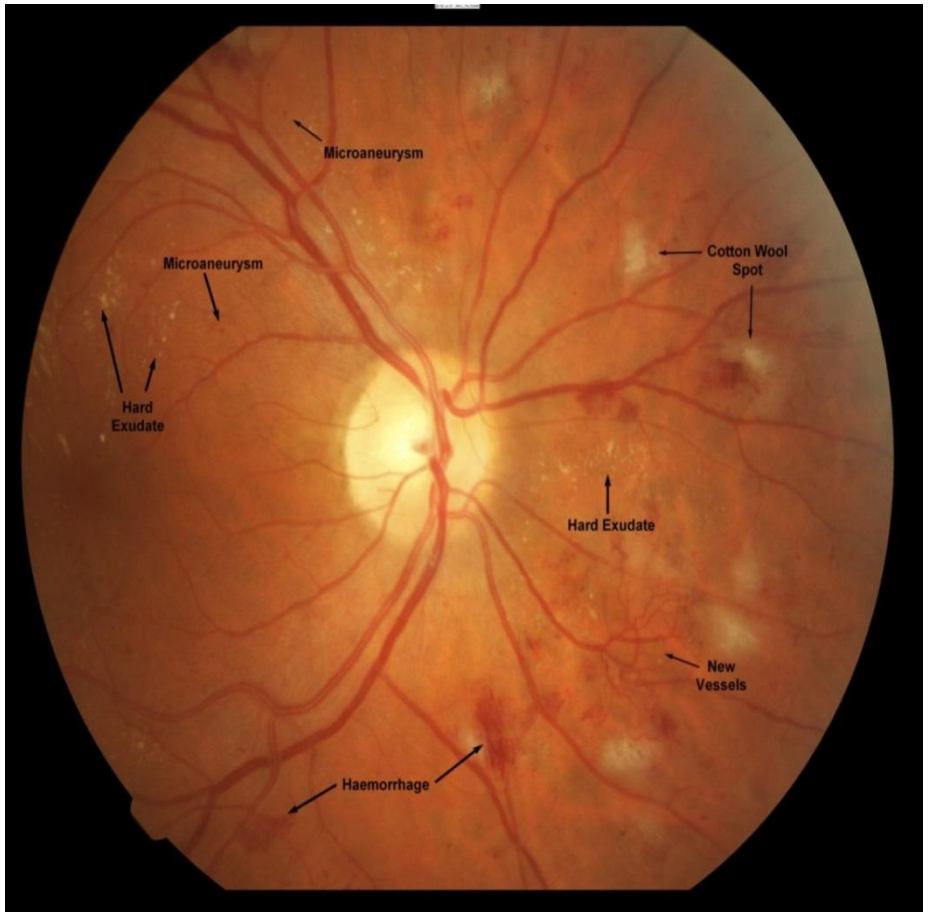
Singapore has one of the highest rates of diabetes globally

- 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) *(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 *(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 *(Mazhar et al, 2010)*

Impact of DR & DME in Singapore

Impact of Diabetic Retinopathy on Vision-Specific Function

Ecosse L. Lamoureux, MSc, PhD,[1,2] E. Shyong Tai, MCRP,[3] Julian Thumboo, FRCP,[4] Ryo Kawasaki, MD, PhD,[1] Seang-Mei Saw, MBBS, PhD,[2,5] Paul Mitchell, MD, PhD,[6] Tien Y. Wong, FRCS, PhD[1,2,6,7]

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 like 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...

The Wisconsin Epidemiologic Study

The Wisconsin Epidemiologic Study of Diabetic Retinopathy XXII

ty-Five-Year Progression of Retinopathy in th Type 1 Diabetes

Michael D. Knudtson, MS,[1] Kristine E. Lee, MS,[1] Ronald Gangnon, PhD,[2]

ression and regression of diabetic retinopathy (DR) and

iving in an 11-county area in southern Wisconsin with ticipated in a baseline examination (1980–1982) and at first follow-up examination

fied Airlie House classifica- ne.

on to proliferative DR (PDR) n less severe DR, male sex, lood with eline, ower lood most ated

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Prevalence of Diabetic Retinopathy in Urban India: The Chennai Urban Rural Epidemiology Study (CURES) Eye Study, I

Mohan Rema, Sundaram R Viswanathan Mohan

PURPOSE. To assess the prevalence of in type 2 diabetic subjects in urban In color photography.

METHODS. The Chennai Urban Ru (CURES) is a population-based study tative population of Chennai (forme India. Individuals ≥20 years in age (*n* for diabetes. Of the 1529 known (90.4%) participated in the study. Subj diabetes (*n* = 354) by the oral gluco also consented to participate in the underwent four-field stereo color ph thy was graded in the color fundus p Early Treatment Diabetic Retinopathy

RESULTS. The overall prevalence of D 17.6% (95% confidence interval [CI cluded 20.8% (95% CI: 18.7–23.1) in and 5.1% (95% CI: 3.1–8.0) in subje diabetes. The prevalence of DR was si than in women (21.3% vs. 14.6%;

Prevalence of Diabetic Retinopathy in India

Sankara Nethralaya Diabetic Retinopathy Epidemiology and Molecu

Rajiv Raman, MS, DN Perumal Gnanamoorth Tarun Sharma, MD,

Objective: The ai population older than ***Design:*** A popula ***Participants:*** Five ***Methods:*** A multi jects with diabetes me the base hospital. The phy. The diagnosis of Retinopathy Study sc ***Main Outcome Me*** retinopathy, and corre ***Results:*** The age 28.2% (95% confiden was 3.5% (95% CI, 3. was 18.0% (95% CI, of diabetic retinopathy

Prevalence and Risk Factors for Diabetic Retinopathy

The Singapore Malay Eye Study

Tien Y. Wong, M Tin Aung, MD, Paul Mitchell, MD

Purpose: To ***Design:*** Popu ***Participants:*** ***Methods:*** Dia medication, or a diabetic retinopat ***Main Outcome*** retinopathy.

Prevalence of Diabetic Retinopathy in Rural China: The Handan Eye Study

Feng Hua Wen Bin W Ning Li W

Purpos

PREVALENCE AND RISK FACTORS FOR DIABETIC RETINOPATHY

Studies show that "classic" risk factors for DR are similar in Asians vs Western populations….

Ronald Klein, MD

• In a populati ern Wisconsin, 1, noses of diabetes were examined using standard protocols to determine the prevalence and severity of diabetic retinopathy and associated risk variables. The prevalence of diabetic

patients are at risk for vision-threatening reti result of microvascular pathologic manifestati

higher total chole retinopathy. Visio 1.24–11.26), card CI, 2.18–9.07). F metabolic and so ***Conclusions:*** Risk factors for re control of these ri ***Financial Disc*** in this article. *Op*

Results results ava with new photograp interval, 3 proliferativ with 12.1 present. T ***Conclu*** rural China persons ag There is a China.

XUE PING DU, MD,‖ YU LIN LI, MD,** YU JI, MD,†† XIAO NING GU, MD,‡‡ YUE LI, MD,§§ SU FANG PAN, MD,* XUE LI CUI, MD,¶¶ WEI BAI, MD,*** YU JIE CHEN, MD,††† ZI MIN WANG, MD,‡‡‡ QING SHENG ZHU, MD,§§§ YING GAO, MD,¶¶¶ DE YUAN LIU, MD,**** YUN TAO JI, MD,†††† ZE YANG, MD,† JOST B. JONAS, MD*‡‡‡‡

Background: To examine prevalence and associated factors of diabetic retinopathy in patients with Type 2 diabetes mellitus in urban communities of Beijing.

Methods: The community health care center–based study included subjects with diabetes mellitus and an age of 20 years to 80 years, who were recruited from 15 community health centers in urban Beijing. Diabetes mellitus was defined using the World Health Organization criteria. Fundus photographs were graded using the modified Airlie House classification system.

…seen in Singapore…(Wong TY et al. 2008)

	Diabetic Retinopathy	*p*	Vision-threatening Retinopathy	*p*
Age, per 10 years	0.73(0.57, 0.93)	0.01	0.61(0.40, 0.94)	0.03
Diabetes duration, per year	1.07(1.04, 1.09)	<0.001	1.08(1.05, 1.11)	<0.001
Serum glucose, per mmol/L	1.05(1.02, 1.09)	0.004	1.10(1.05, 1.17)	<0.001
HbA1c, per mmol/L	1.21(1.10, 1.33)	<0.001	1.23(1.06, 1.42)	0.007
Systolic BP, per 10 mmHg	1.17(1.08, 1.28)	<0.001	1.35(1.18, 1.55)	<0.001
Pulse pressure, per 10 mmHg	1.34(1.19, 1.51)	<0.001	1.73(1.42, 2,11)	<0.001
Total cholesterol, per mmol/L	0.75(0.63, 0.89)	0.001	1.12(0.88, 1.42)	0.36
Body mass index, per kg/m^2	0.96(0.92, 1.00)	0.08	0.93(0.86, 1.00)	0.04
Previous myocardial infarction	1.57(0.88, 2.81)	0.13	2.29(0.90, 5.83)	0.08
Previous stroke	1.06(0.48, 2.34)	0.88	3.74(1.24, 11.3)	0.02
Cardiovascular disease	1.22(0.77, 1.94)	0.40	2.23(1.08, 4.62)	0.03
Chronic kidney disease	1.48(0.99, 2.21)	0.06	4.45(2.18, 9.07)	<0.001

*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)

	P	Odds Ratio	95% CI
Age (per year)	<0.001	0.97	0.95–0.98
Duration of diabetes (per year)	<0.000	1.10	1.08–1.12
Glycosylated hemoglobin (per 1 mmol/L)	<0.000	1.23	1.14–1.33
Systolic blood pressure (mmHg)	0.004	1.01	1.01–1.02
Body mass index (kg/m^2)	0.002	0.95	0.92–0.98
Blood urea nitrogen (mmol/L)	0.02	1.01	1.00–1.01

…in rural China..(Wang FH et al. 2011)

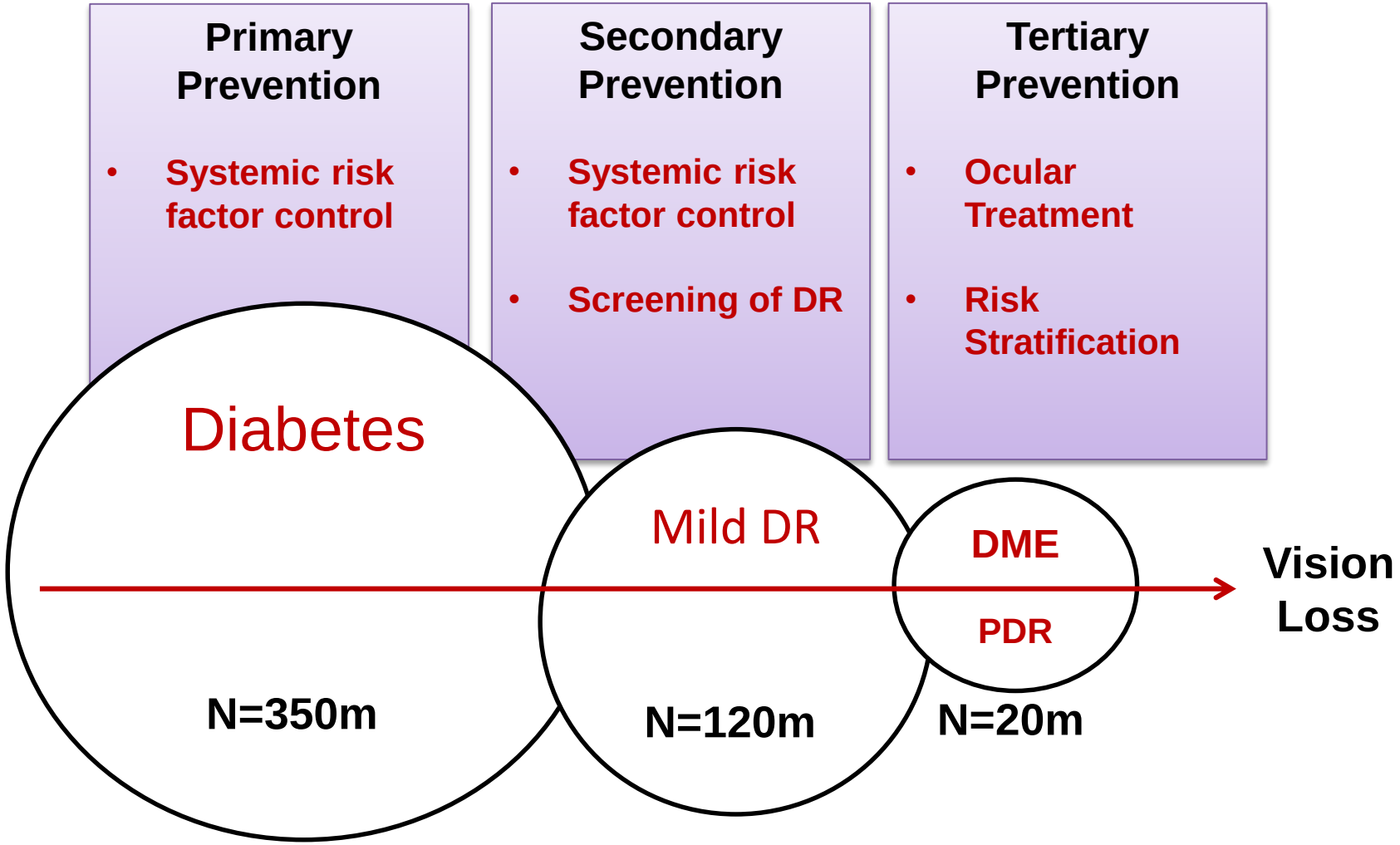
Diabetic Retinopathy	Odds Ratio (95% CI)	P Value
All Diabetes†		
Age	0.98 (0.96-1.01)	0.23
Duration of diabetes, per 5 years	3.07 (1.94-4.85)	<0.001
Fasting plasma glucose, per mmol/l	1.17 (1.08-1.27)	<0.001
Systolic blood pressure, per 10 mmHg	1.22 (1.08-1.37)	0.001
Newly diagnosed Diabetes‡		
Age	1.00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

† 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**

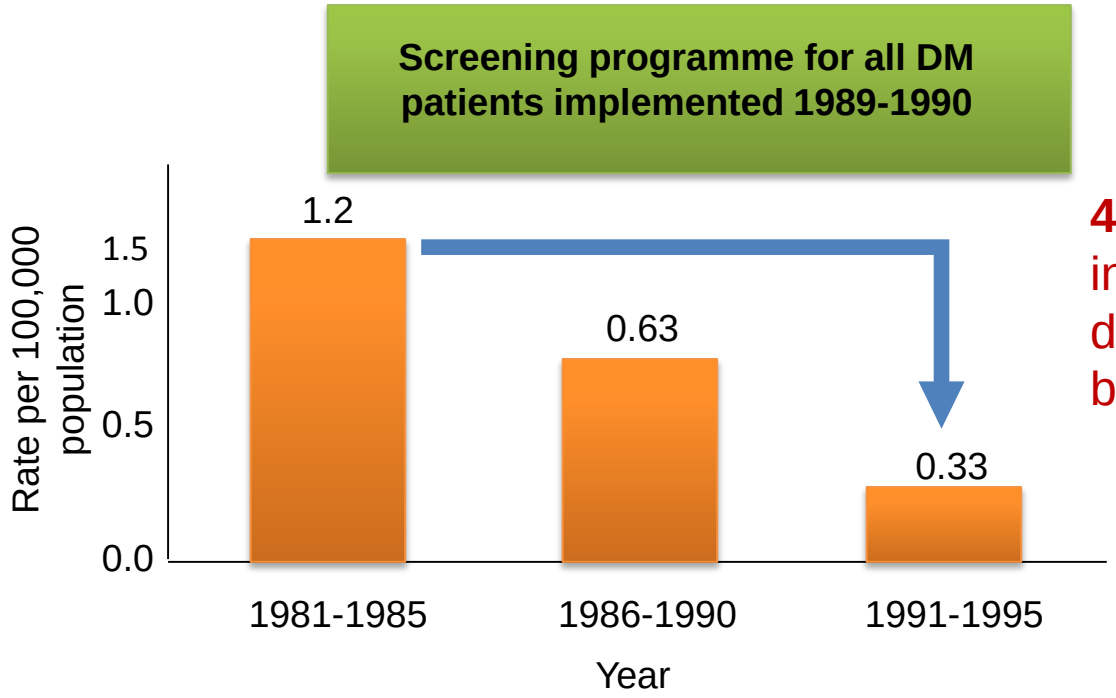
From Epidemiology to Screening



DR screening works!

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

Bäcklund LB et al. Diabet Med. 1997;14(9):732-40.



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.[1] Laser coagulation of high risk lesions detected by screening can significantly reduce the likelihood of blindness and deteriorating vision.[2 3] 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,[3 4] 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 population coverage, one by a hospital based retinal

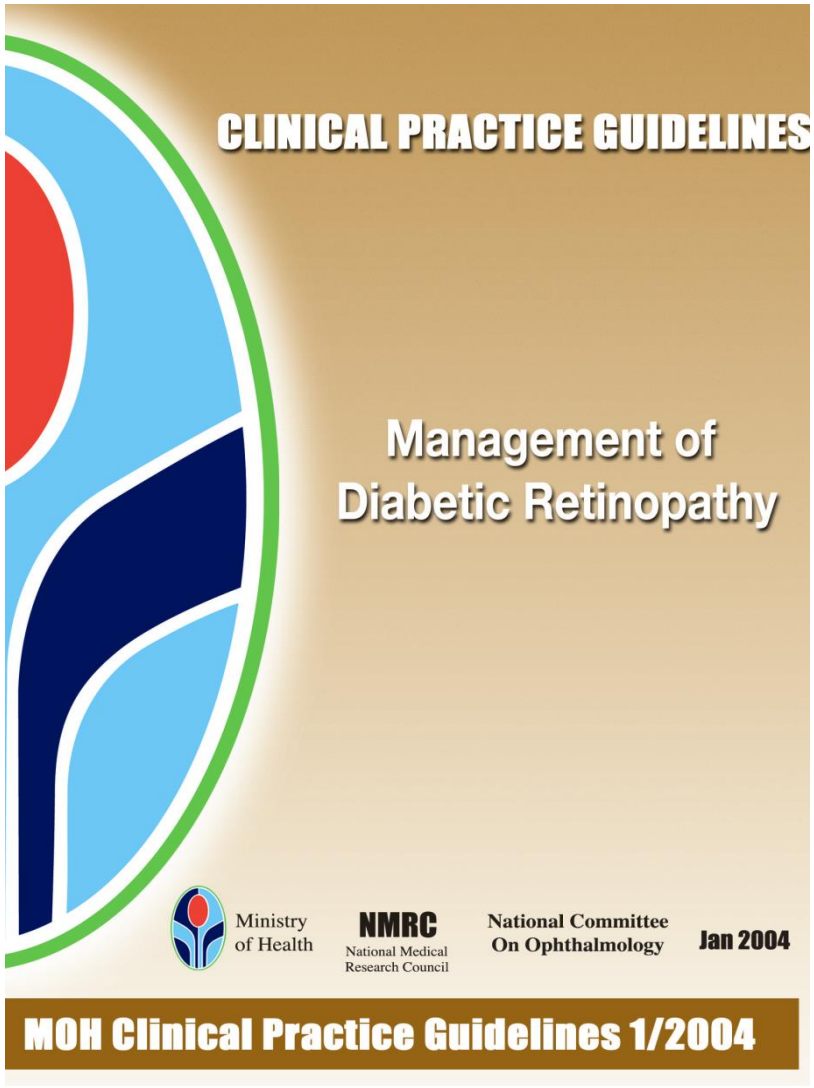
NHS Diabetic Eye Screening Programme

2011-12 Summary

1 April 2011 - 31 March 2012

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**

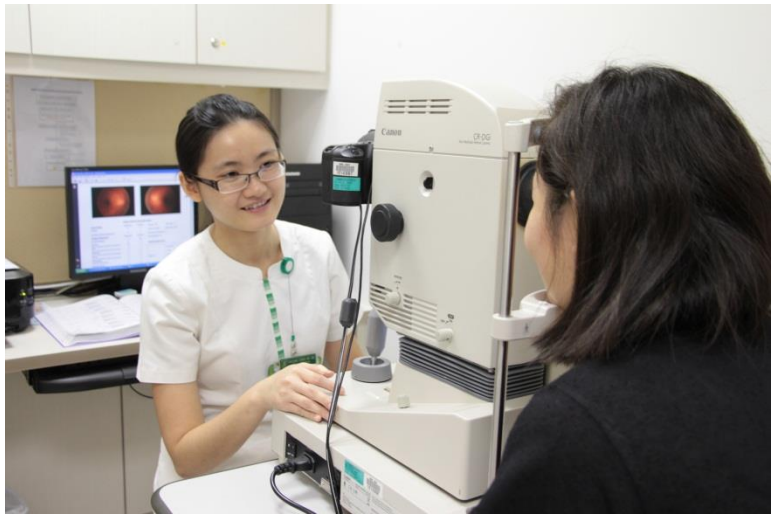
Limitations of Current Polyclinic Model

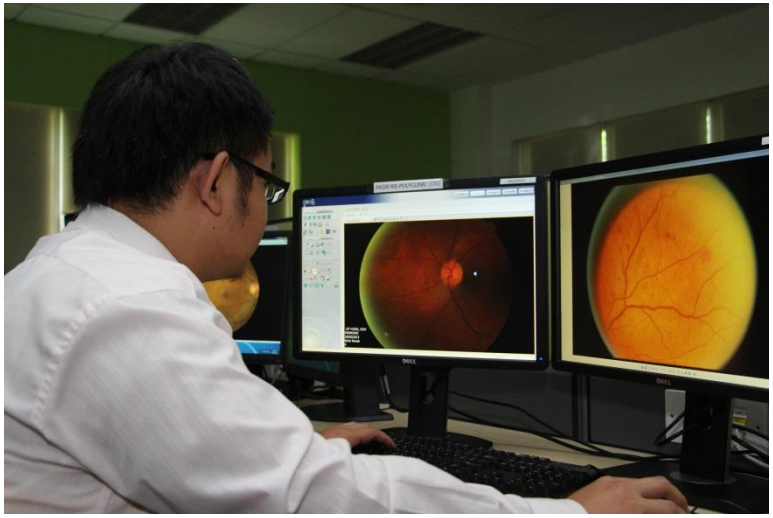
- **Cost-ineffective** as physicians are made to assess DR when this can be performed by trained technicians or optometrists
- **Lack of time** for physicians to grade images, resulting in delays in detection and referral
- **Inconsistencies in the grading outcomes** with no standardized protocol and 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”

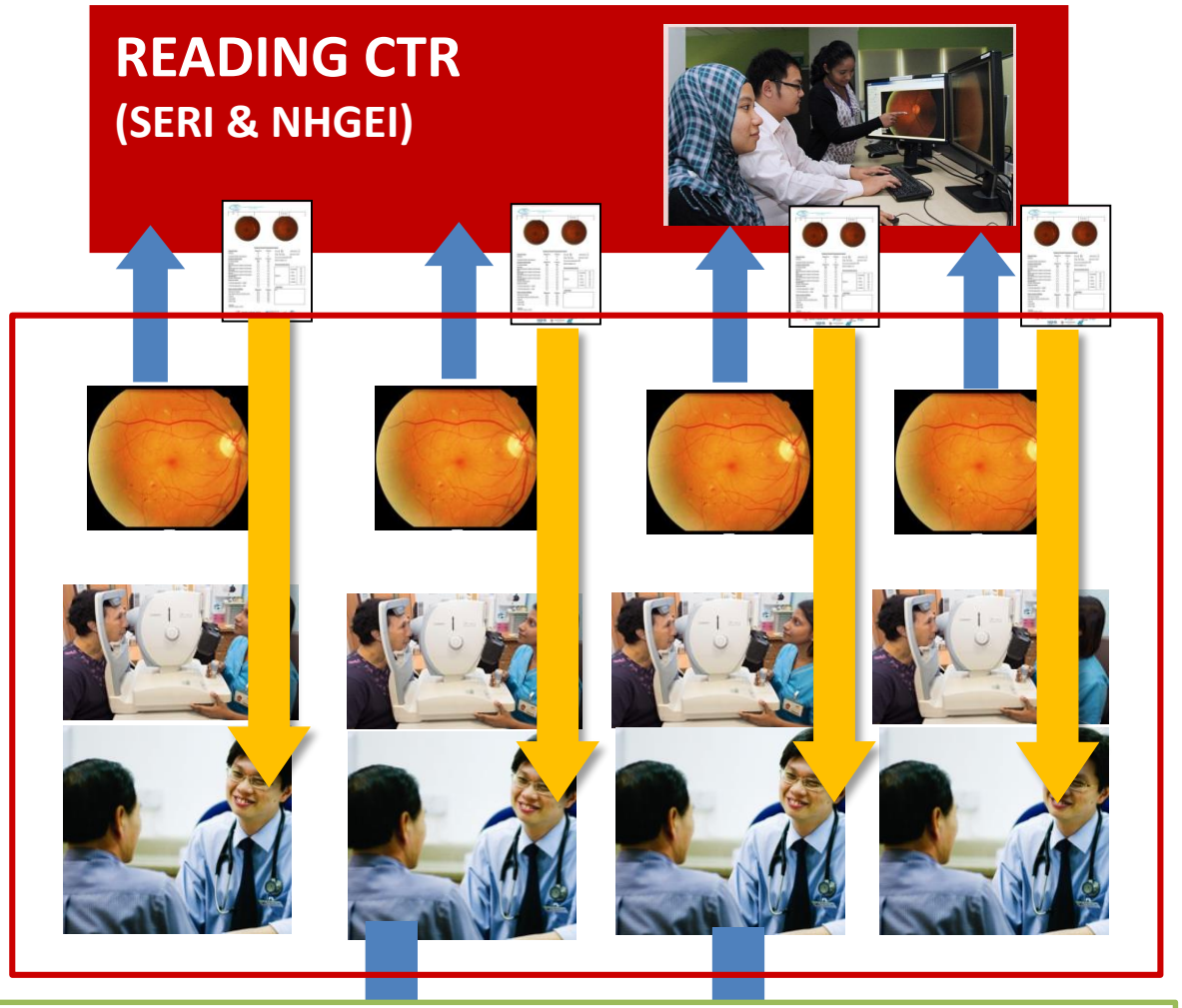




SiDRP Concepts

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



Primary Care Clinics, equipped with retinal cameras (N=18, covering 200K DM patients)

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)

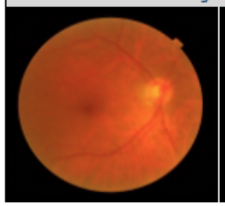
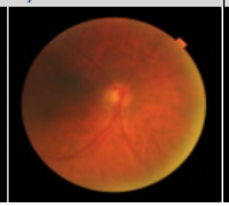
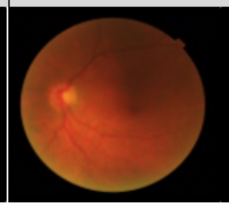
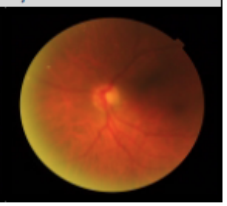
Patient & Physician Report

SiDRP

SINGAPORE INTEGRATED DIABETIC RETINOPATHY PROGRAMME

Diabetic Retinopathy Photography Report

Patient Details			
Patient ID	S6969696A	Patient Name	ALI BIN AHMAD
Date of Birth	27-Sep-1945 (70 Y 11 M)	Gender	MALE
Visit No	MP123456789	Location	Marine Parade Polyclinic
Screening Date/Time	24-Sep-2016 12:06	Reported Date/Time	24-Sep-2016 12:10

Right Eye		Left Eye	
			

Visual Acuity				
	Right Eye		Left Eye	
VA (Glasses)	6/9		6/9	
Dilation Performed	No			
Retinal Assessment				
Fundus Image Quality	Gradable		Gradable	
Vision and Media Opacity	No media opacity with VA better than 6/18		No media opacity with VA better than 6/18	
Diabetic Retinopathy	No		No	
Diabetic Maculopathy	No		No	
Treated Diabetic Retinopathy	No		No	
Age Related Macular Degeneration	No		No	
Cup Disc Ratio	0.5		0.5	
Glaucoma Suspect	No Glaucoma Features		No Glaucoma Features	
Other Ocular Conditions	No		No	
Other Incidental Finding(s)	No		No	
Other Referable Condition(s)	No		No	
Graded By	Darren Ong Kok Soon (Primary Grader)			

Recommended Patient Management Plan			
Main Findings	Right Eye:- Within non-referable limits Left Eye:- Within non-referable limits		
Follow-Up Action	Normal screening result. Recommended annual regular eye screening	Additional Action	
Other Referable Condition(s)	No		
Remarks			

Reading Centre provides **the recommended action**.

Physicians would then interpret the results and provide the **relevant diagnosis** to the patient and **manage/refer accordingly**.

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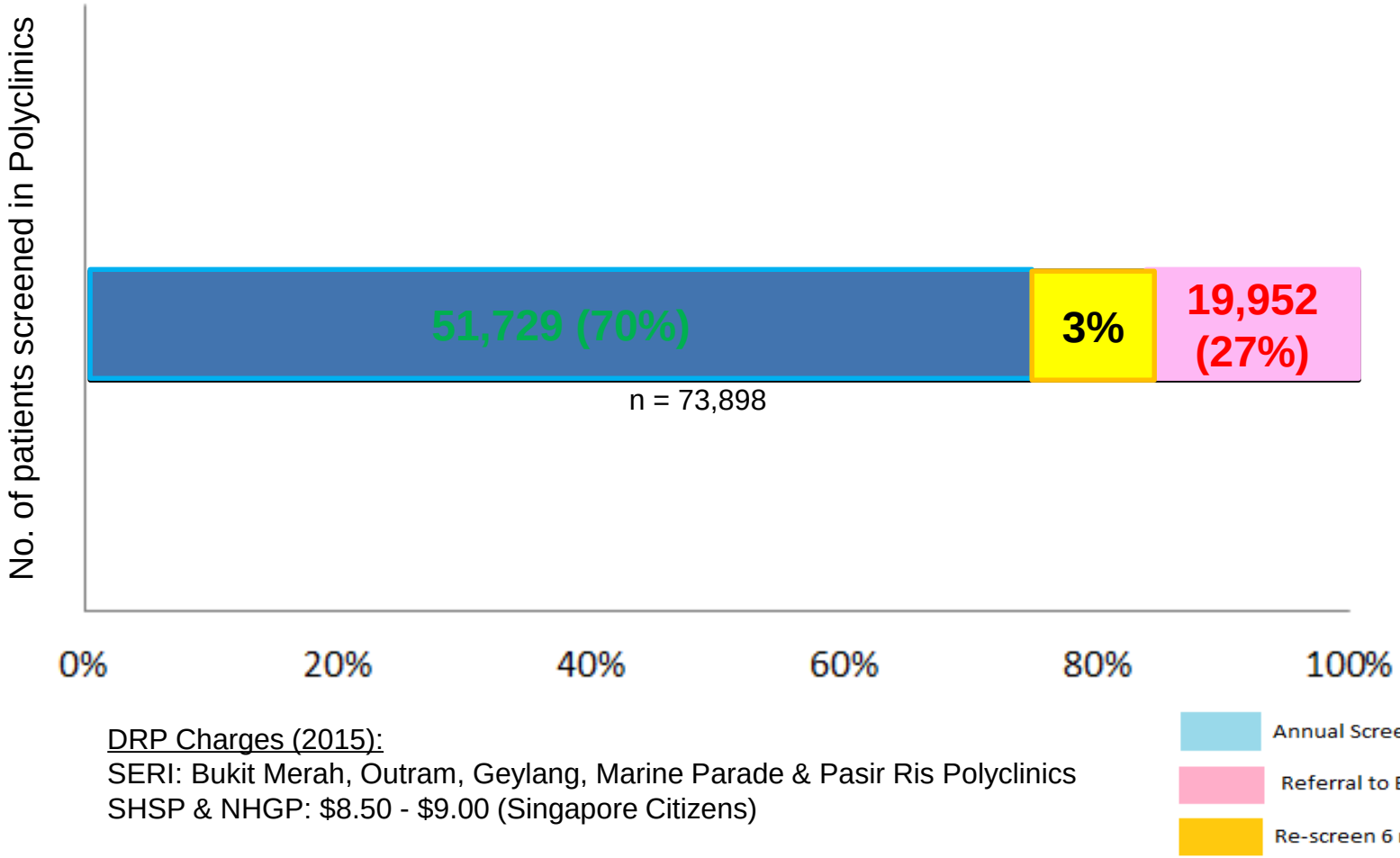
SIDRP- Screening and Referral for 2016

As of 3rd March 2017



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

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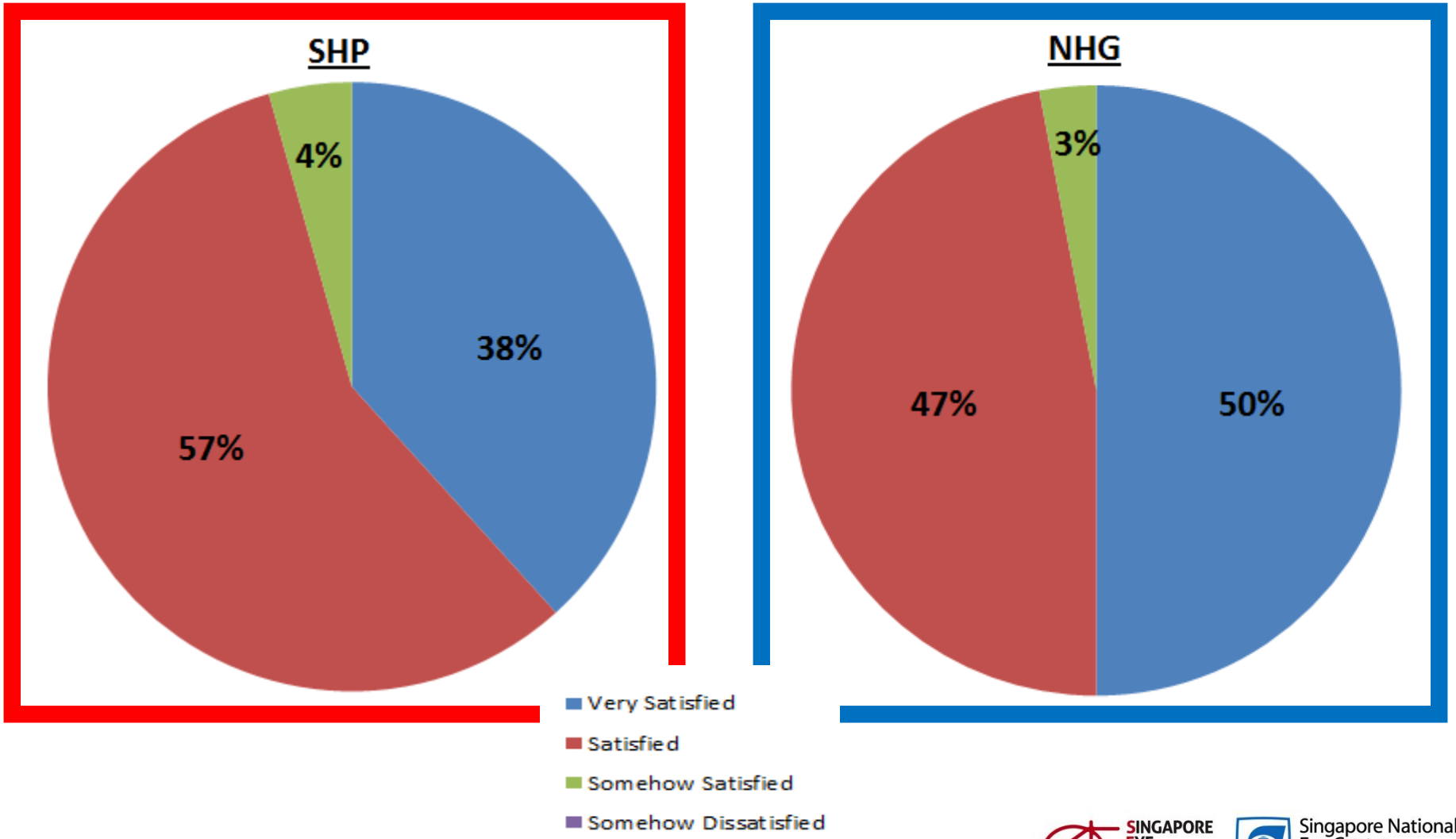
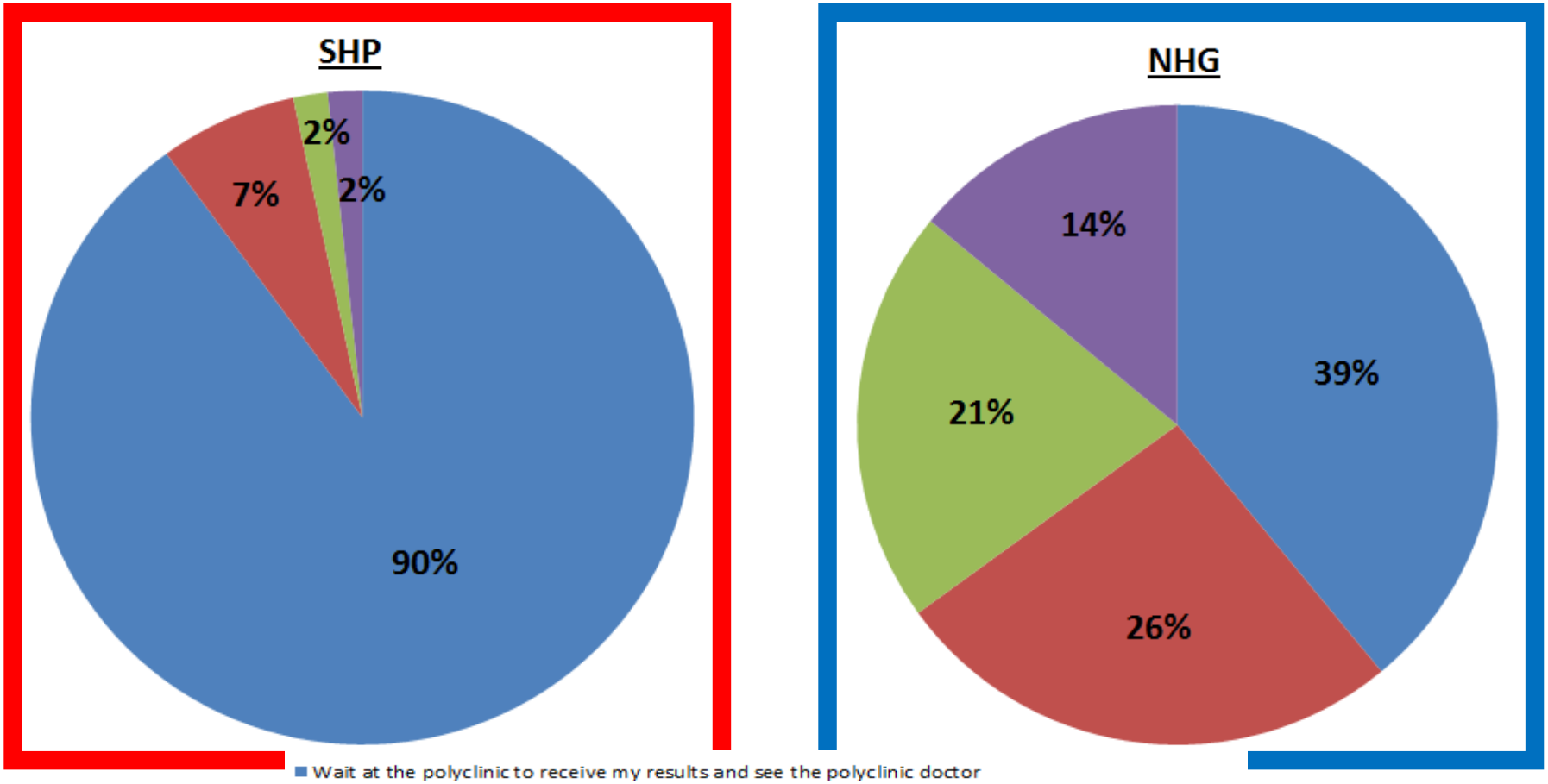
Key Outcomes

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

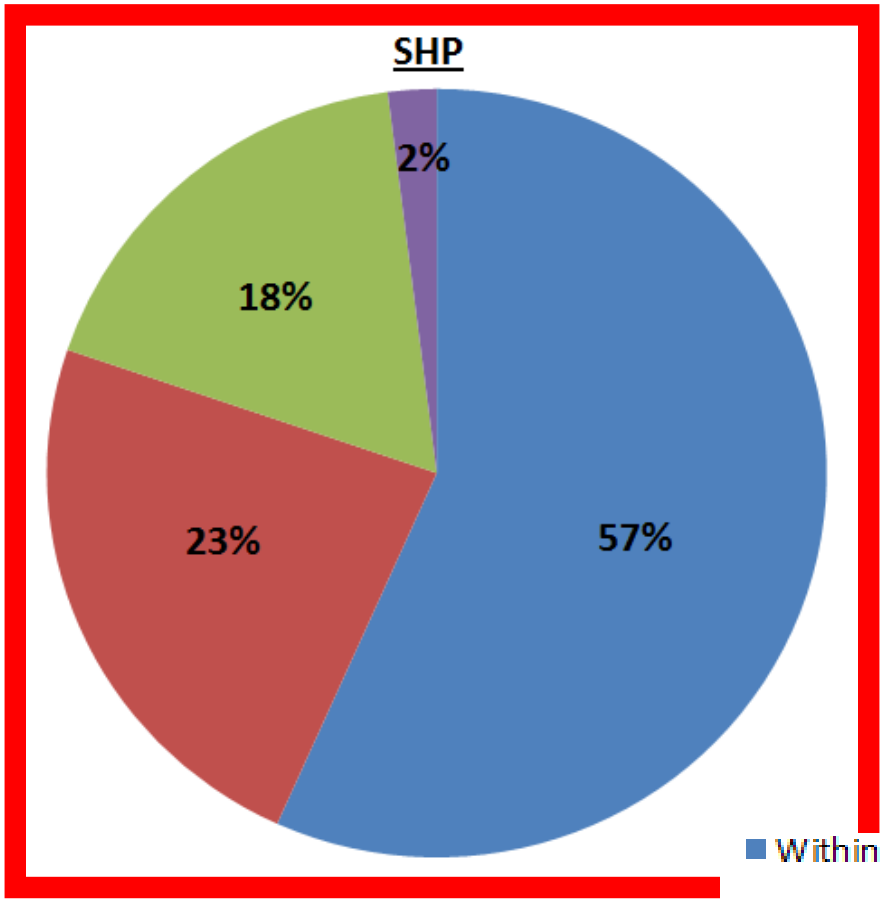
How satisfied were you with the current DR eye-screening service?

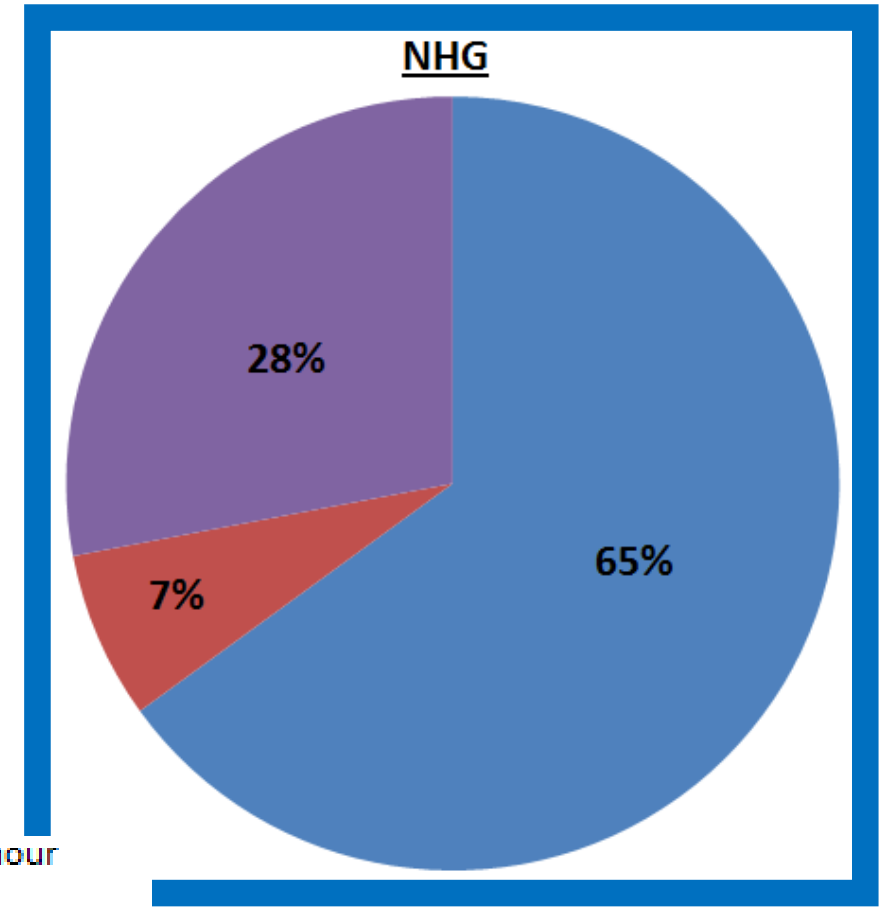


What is your preferred method of receiving your DR eye screening results if abnormal?



If you prefer to wait for results at the polyclinic, what is the longest time you are willing to wait?





Within 1 hour
1-2 hours
More than 2 hours
No opinion

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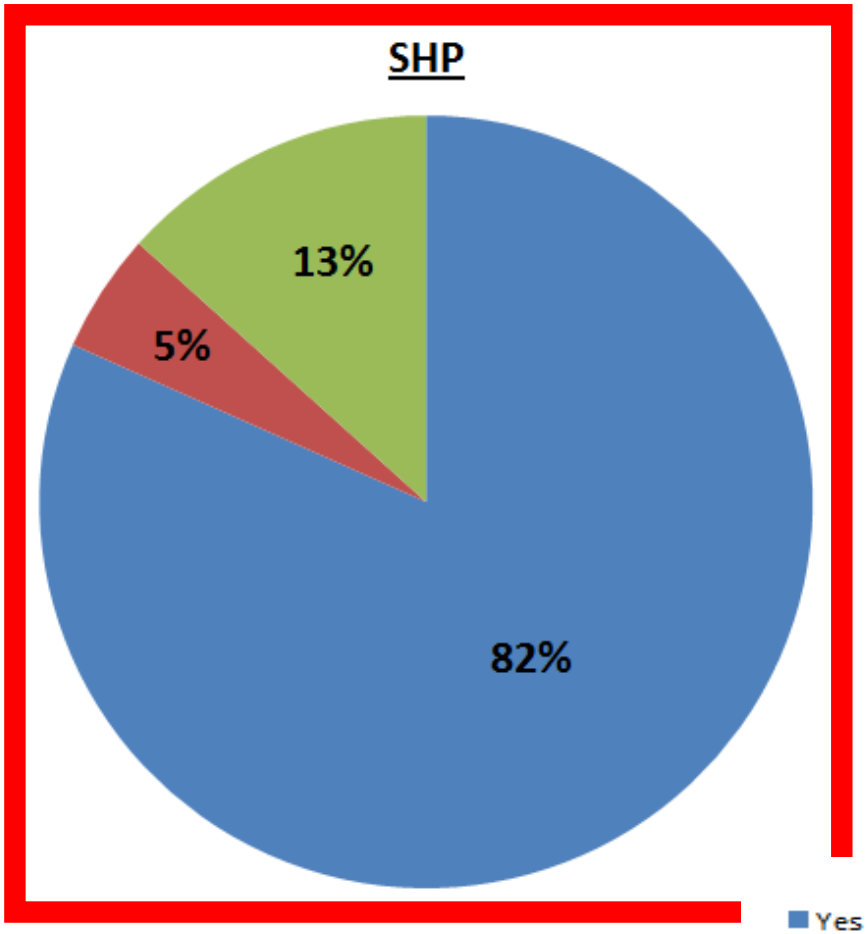

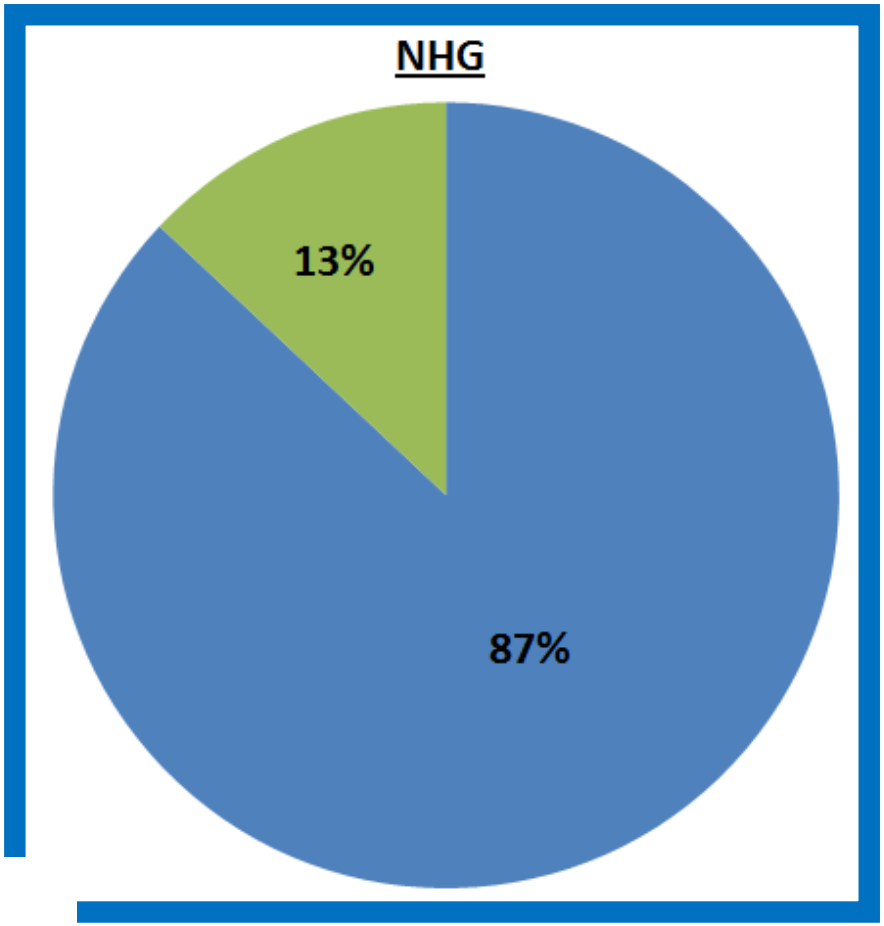

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COST EFFECTIVENESS ESTIMATES: SIDRP VERSUS FAMILY PHYSICIANS

Cost-effectiveness of a National Telemedicine Diabetic Retinopathy Screening Program in Singapore

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Purpose: To determine the incremental cost-effectiveness of a new telemedicine technician-based assessment relative to an existing model of family physician (FP)—based assessment of diabetic retinopathy (DR) in Singapore from the health system and societal perspectives.

Design: Model-based, cost-effectiveness analysis of the Singapore Integrated Diabetic Retinopathy Program (SiDRP).

Participants: A hypothetical cohort of patients aged 55 years with type 2 diabetes previously not screened for DR.

Methods: The SiDRP is a new telemedicine-based DR screening program using trained technicians to assess retinal photographs. We compared the cost-effectiveness of SiDRP with the existing model in which FPs assess photographs. We developed a hybrid decision tree/Markov model to simulate the costs, effectiveness, and incremental cost-effectiveness ratio (ICER) of SiDRP relative to FP-based DR screening over a lifetime horizon. We estimated the costs from the health system and societal perspectives. Effectiveness was measured in terms of quality-adjusted life-years (QALYs). Result robustness was calculated using deterministic and probabilistic sensitivity analyses.

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.

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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.

Acknowledgements

Singapore Eye Research Institute

- Prof. Ecosse Lamoureux
- Prof. Wong Tien Yin
- A/Prof. Cheng Ching-Yu
- Dr Charumathi Sabanayagam
- Dr Ryan Man
- Dr Gavin Tan
- Dr Daniel Ting
- Dr Eva Fenwick.

Funding Source

Singapore Ministry of Health's National Medical Research Council-Multiple grants.

Thank You!