

Research paper

Periodic Blood Glucose Test and its Relationship with Diabetic Retinopathy Among Patients with Diabetes in a Tertiary Ophthalmic Centre

You Chuen Chin^{1,2}, Srinivasan Sanjay^{1,3*}, Ee Lin Ong⁴, Sun Yan⁵, Kah Guan Au
Eong^{1,6}

¹. Department of Ophthalmology and Visual Sciences, Khoo Teck Puat Hospital, 90
Yishun Central, Singapore 768828

². Yong Loo Lin School of Medicine, National University of Singapore, 1E Kent Ridge
Road, Singapore 119228

³. Eye Clinic, Jurong Medical Centre, 60 Jurong West Central 3, Singapore 648346

⁴. Department of Ophthalmology, Tan Tock Seng Hospital, 11 Jalan Tan Tock Seng,
Singapore 308433

⁵. Health Services Outcome Research, GMTI Building, 6 Common Wealth Lane, #04-
01/02, Singapore 149547

⁶. Singapore International Eye Cataract Retina Centre, Singapore International Eye
Cataract Retina Centre, 3 Mount Elizabeth #07-04, Mount Elizabeth Medical Centre,
Singapore 228510

*Corresponding author:

Dr S Sanjay

Department of Ophthalmology and Visual Sciences, Khoo Teck Puat Hospital, 90
Yishun Central, Singapore 768828

ABSTRACT

Aim: To assess the awareness of periodic blood glucose test and its relationship with diabetic

28 retinopathy among adult diabetic patients attending a tertiary ophthalmic centre.

29 **Study design:** Cross-sectional study

30 **Place and Duration of Study:** Ophthalmology and Visual Sciences, Alexandra Hospital,

31 between January and February 2007

32 **Methodology:** An interviewer-administered survey was conducted among 506 participants
33 with diabetes mellitus, aged 23 to 88 years old. Awareness of periodic blood glucose test and
34 diabetic retinopathy was assessed via the survey.

35 **Results:** Only 296 (58.5%) participants were aware of the relationship between periodic
36 blood glucose test and diabetic retinopathy. Participants who were Indians ($p=.01$) and had a
37 highest education level of primary school ($p=.04$) were less aware. However, participants with
38 higher education had higher awareness ($p=.01$). The age- and gender-adjusted odds ratio
39 (OR) of having diabetic retinopathy was 0.54 (95% confidence interval (CI): 0.38-0.78,
40 $p=.001$). On multivariate adjustment, results remained statistically (OR: 0.49, CI: 0.31-0.77,
41 $p=.002$).

42 **Conclusion:** Periodic blood glucose test awareness is lower in Indians and those who were
43 less educated. Participants who were aware of periodic blood glucose test were less likely to
44 have diabetic retinopathy.

45 **Keywords:** Diabetic retinopathy, blood glucose test, awareness, Singapore

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56 1. INTRODUCTION

57 Diabetes mellitus results in considerable morbidity and mortality, affecting about 180 million

58 people worldwide.¹ It is predicted that the prevalence will rise to an estimated 300 million
 59 cases by 2025 and this may be a cause for public concern.² Diabetic retinopathy represents a
 60 leading cause of blindness in adults who are under the age of 75 years.³ This increase is
 61 compounded by a lack of awareness of diabetes mellitus and the risk factors and
 62 complications associated with it.⁴ A study by Tham et al⁵ showed that 25% of patients with
 63 diabetes were ignorant of some key aspects of diabetes such as the need for home glucose
 64 monitoring and regular ophthalmic reviews.

65
 66 Wang et al⁶ found that a lack of patient awareness of increased glycated haemoglobin
 67 (HbA1c) is a major contributing factor to poor compliance with guidelines to keep HbA1c <7%.
 68 It is paramount to address this issue as the number of persons with diabetes has been
 69 anticipated to increase, particularly in Asian countries.⁷ In addition, HbA1c or periodic blood
 70 glucose test (3 monthly) provides an indication to physicians regarding the effectiveness of
 71 current diabetic management.⁸ In the present study, we assessed the awareness of a periodic
 72 blood glucose test and diabetic retinopathy in a hospital-based survey of Singapore residents
 73 with diabetes. Knowledge of the factors associated with less awareness between periodic
 74 blood glucose test and diabetic retinopathy can help us to this group of people, and hence,
 75 aim to improve awareness among them.

76

77 **2. METHODOLOGY**

78 **2.1 Study population**

79 A hospital-based, cross-sectional study of 506 participants aged between 23 and 88 years old
 80 in Singapore, was conducted between January and February 2007. The patients were
 81 existing eye patients or were referred to the eye clinic for diabetic retinopathy screening.
 82 Participants were asked about awareness of periodic blood glucose test. The survey
 83 population consisted of ethnic Chinese, Malay, Indian and other racial groups. Our inclusion
 84 criteria included patients who were not aware of the term HbA1c as we wanted to distinguish
 85 those who were familiar with the term HbA1c and periodic blood glucose test, patients who
 86 were willing to participate in the study and able to give consent. Exclusion criteria included
 87 patients who were unwilling to participate, unable to give consent, or when there was

88 unavailability of a suitable interpreter of the spoken language.

89

90 Verbal consent was sought prior to the interview. An interpreter was enlisted to facilitate the
91 conversation when required. The interpreter was well versed with the questionnaire and could
92 answer the patient queries. The questionnaire replies could be elicited on an average of 10-
93 15 minutes per patient.

94

95 **2.2 Questionnaire**

96 A trained interviewer administered standard questionnaire surveys to consecutive patients
97 with diabetes attending a tertiary ophthalmic centre. Awareness of periodic blood glucose test
98 and diabetic retinopathy were assessed using the questions below which are a truncated
99 portion of our survey.

100

101 1. What is your highest education level attained?

102 2. What is your occupation?

103 3. Are you aware that you have diabetic retinopathy?

104 4. Have you done any laser treatment to the eye as a result of diabetic eye complications?

105 5. Who do you follow-up with for your diabetes? A family physician or endocrinologist?

106 6. Are you aware that diabetes can cause blindness?

107 7. Are you aware that increased blood glucose can cause blindness?

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109 Questions 1-2 were open-ended while for questions 3-7, patients answered 'yes', 'no' or 'don't
110 know'. Survey answer 1, 2 and 4 were cross-checked by the clinician (Dr Sanjay Srinivasan)
111 with the patient's record to ensure accuracy.

112

113 **2.3 Statistical analysis**

114 All statistical tests were performed using the Statistical Package for the Social Sciences (v.
115 15.0 SPSS Inc., STATE, USA). The distributions of patient characteristics were analysed
116 using univariate analysis (chi-square and ANOVA test). Logistic regression models were used
117 to assess the awareness of periodic blood glucose test within each stratum and association

118 between awareness of periodic blood glucose test and diabetic retinopathy. Results were
 119 adjusted for the different models; model 1 comprised age and gender; model 2 comprised
 120 variables in model 1 and race, education, diabetes duration, and care by endocrinologist or
 121 family physician. Associations were presented as odds ratio (OR) with corresponding 95%
 122 confidence intervals (CI). A p-value of <0.05 was taken to be statistically significant.

123

124 3. RESULTS

125 Out of 623 patients invited to participate in the survey, 507 were recruited for the primary
 126 study (81.2% response rate). One patient was excluded due to incomplete data, leaving only
 127 506 sets of data. The majority of patients who declined to participate cited a lack of time or
 128 interest in the study. Details of the non-participants could not be obtained as they refused to
 129 participate.

130

131 Table 1 shows the demographical data of our participants. There were 257 (50.8%) men and
 132 249 (49.2%) women. The mean age of the participants was 62.1 years (range: 23 to 88
 133 years). The education level of the participants ranged from no formal education to a
 134 postgraduate degree with 156 (30.8%) having completed at least secondary level. Of the
 135 patients, 272 (53.8%) had diabetic retinopathy and 132 (26.1%) had previous laser treatment.
 136 There were 296 (58.5%) patients who were aware of the relationship between periodic blood
 137 glucose test and diabetic retinopathy.

138

139 **Table 1.** Demographic data of the patients (n=506)

Characteristics of participants	Mean (SD) or n (%)			
	All participants	Aware of periodic blood glucose test (n=296)	Not aware of periodic blood glucose test (n=210)	P-value

Age, years	62.1 (11.7)	60.7 (12.2)	64.1 (10.7)	0.001
Gender, % men	257 (50.8)	158 (53.5)	99 (47.1)	0.176
Race				0.016
Chinese	333 (65.8)	202 (68.2)	131 (62.4)	
Malay	98 (19.4)	44 (14.9)	54 (25.7)	
Indian	71 (14.0)	47 (15.9)	24 (11.4)	
Others	4 (0.8)	3 (1.0)	1 (0.5)	
Highest educational level attained				<0.001
No formal education	166 (32.8)	91 (30.7)	75 (35.7)	
Completed primary education	184 (36.4)	89 (30.1)	95 (45.2)	
Completed secondary education/Completed N/O levels	99 (19.6)	66 (22.3)	33 (15.7)	
Completed Pre university/Junior college/A levels	38 (7.5)	34 (11.5)	4 (1.9)	
Completed polytechnic/diploma	14 (2.8)	12 (4.1)	2 (1.0)	
Completed bachelors/university degree	3 (0.6)	2 (0.7)	1 (0.5)	
Completed post graduate degree	2 (0.4)	2 (0.7)	0 (0)	
Occupation				0.013
Self employed	14 (2.8)	12 (4.1)	2 (1.0)	
Employee	121 (23.9)	82 (27.7)	39 (18.6)	
Unemployed	47 (9.3)	28 (9.5)	19 (9.0)	

Full time student	4 (0.8)	3 (1.0)	1 (0.5)	
Retired	320 (63.2)	171 (57.8)	149 (71.0)	
HbA1c, %	7.68 (1.4)	7.8 (1.5)	7.4 (1.2)	0.104
Diabetes duration, years	10.2 (6.7)	10.3 (7.2)	10.1 (5.9)	0.794
Diabetic retinopathy, %	272 (53.8)	177 (59.7)	95 (45.2)	0.002
Laser treatment	132 (26.1)	97 (32.8)	35 (16.7)	<0.001
Care by family physician	307 (60.7)	151 (51.0)	156 (74.3)	<0.001
Care by Endocrinologist	236 (46.6)	171 (57.8)	65 (31.0)	<0.001
Aware that diabetes could cause blindness	212 (41.9)	153 (51.7)	59 (28.1)	<0.001
Aware that they were having diabetic retinopathy	220 (43.5)	143 (48.3)	77 (36.7)	0.017

140

141 Comparing the awareness of periodic blood glucose test and its relationship with patient
 142 characteristics, there were significant differences among patients of different age ($p=.001$),
 143 race ($p=.02$), education ($p<0.001$), occupation ($p=.01$), There was significantly greater
 144 awareness among patients with younger age ($p=.001$), presence of diabetic retinopathy
 145 ($p=.002$), having undergone laser treatment ($p<0.001$), care for by family physician or
 146 endocrinologist ($p<0.001$) and being aware that diabetes could cause blindness ($p<0.001$).

147

148 Logistic regression performed (Table 2) found that Indians (OR: 0.5, 95% CI: 0.3-0.9, $p=.01$)
 149 and participants with a highest education level of primary school (OR: 0.6, 95% CI: 0.4-1.0,
 150 $p=.04$) were less aware of periodic blood glucose test. However, participants who have
 151 completed pre-university/junior college/A levels have higher awareness (OR: 4.4, 95% CI:

152 1.4-13.7, p=.01).

153

154 **Table 2.** Stratified analysis on Participant Characteristics on Awareness of Periodic Blood

155 Glucose Test

	OR (95% CI)	P-value
Age	1.0 (1.0 – 1.0)	0.105
Gender		
Female	1.0	
Male	1.1 (0.7-1.6)	0.731
Race		0.041
Chinese	1.0	
Malay	1.0 (0.6-1.8)	0.990
Indian	0.5 (0.3-0.9)	0.013
Others*	-	-
Highest educational level attained		
No formal education	1.0	
Completed primary education	0.6 (0.4-1.0)	0.042
Completed secondary education/Completed N/O levels	1.3 (0.7-2.3)	0.405
Completed Pre university/Junior college/A levels	4.4 (1.4-13.7)	0.012
Completed polytechnic/diploma	3.3 (0.7-16.1)	0.133
Completed bachelors/university degree*	-	-
Completed post graduate degree*	-	-
Diabetes duration, years	1.0 (1.0-1.0)	0.601
Care by family physician	1.0 (0.9-1.2)	0.627
Care by Endocrinologist	1.0 (0.8-1.2)	0.992

156 *There were less than 5 participants in this group

157

158 Table 3 shows the adjusted OR together with 95% CI for diabetic retinopathy with respect to

159 the different models. For diabetic retinopathy, the age- and gender-adjusted OR for having

160 diabetic retinopathy per SD increase in awareness is 0.54 (95% CI: 0.38-0.78, p=.001). After

adjusting additionally for race, education, occupation, diabetes duration, care by family physician, care by endocrinologist and being aware that diabetes causes blindness, results remained statistically significant (OR: 0.49, 95% CI: 0.31-0.77, $p=0.002$).

Table 3. Relationship of Awareness of Periodic Blood Glucose Test with Diabetic Retinopathy

	OR (95% CI)	P-value
DR		
Model 1	0.54 (0.38-0.78)	0.001
Model 2	0.49 (0.31-0.77)	0.002

OR = Odds Ratio, CI = Confidence Interval, DR = Diabetic retinopathy

Model 1: Age-, gender- adjusted

Model 2: Model 1, race, education, occupation, diabetes duration, care by family physician, care by endocrinologist, aware that diabetes causes blindness

4. DISCUSSION

In order to reduce and prevent diabetic retinopathy, the extent of patient awareness is of utmost importance. However, our study shows that knowledge of the periodic blood glucose test and its relationship with diabetic retinopathy is relatively low (52.0%) amongst patients attending a tertiary ophthalmic centre.

Our study showed that a high education level (tertiary and above) is associated with greater awareness of the link between higher blood glucose and diabetic retinopathy (OR 4.4, 95% CI 1.4-13.7, $p=0.01$). Similarly, in a study by Muecke et al⁹, compared with tertiary-educated patients with diabetes, those who had never attended school were less likely to see an endocrinologist (OR 0.24; 95% CI 0.09-0.66) and hence, less awareness of the association between higher blood glucose and diabetic retinopathy.

In a study by Huang et al¹⁰ among the Singaporean Malay population on the awareness of diabetes, high proportions of patients with diabetes (83.4%) were unaware that they had diabetic retinopathy. Also, the lack of awareness was linked to poorer control of diabetic

187 retinopathy risk factors.¹⁰ Similarly, Zgibor and Simmons¹¹ demonstrated that a better grading
 188 on the Diabetes Knowledge Test is associated with lower blood glucose values, and HbA1c
 189 levels. However, in our study, we found that participants who were aware of periodic blood
 190 glucose test had higher HbA1c (7.8% vs 7.4%), but this was not statistically significant
 191 ($p=.104$). Huang et al¹⁰ also found that only a mere half of study population among Malays
 192 who were unaware that they had diabetic retinopathy had received laser treatment.¹⁰ We
 193 found that a significant proportion of participants who were unaware of periodic blood glucose
 194 test had laser treatment (16.7% vs 32.8%, $p=.001$). This could be due to more participants
 195 who were aware of blood glucose test, having diabetic retinopathy (59.7% vs 45.2%, $p=.002$).

196

197 Self-monitoring of blood glucose levels is an essential part of the intensive management
 198 required to optimize glucose control,¹² and thus, diabetes education may play a vital role in
 199 preventing diabetic retinopathy.¹³ Also, patients with diabetes should be educated on the
 200 need for regular ophthalmic examinations to effectively prevent diabetic retinopathy. In order
 201 to increase participation rates in annual eye examination among diabetics, Brechner et al¹⁴
 202 showed that attending a diabetes education class helps increase participation rate.

203

204 Several limitations of our study need to be discussed. Firstly, this is a cross-sectional design
 205 which does not allow us to investigate whether participants who were aware of periodic blood
 206 glucose test were less likely to have diabetic retinopathy or vice versa. Secondly, we were
 207 unable to obtain information about non-participants for comparison. Thirdly, a high
 208 percentage of our participants (90%) had a highest education level of O levels or less, this
 209 limits our analysis of participants with education levels higher than O levels. The strengths of
 210 this study are a high response rate (81.2%) and the use of standardized surveys.

211

212 During the course of this study, we encountered some difficulties in explaining what a periodic
 213 blood glucose test was to subjects who were unaware of HbA1c and in explaining that
 214 periodic blood glucose test is not the routine blood glucose test done daily. The use of flow
 215 charts, bar diagrams or pamphlets would have been a good aid in answering our research
 216 question. We are considering how to explain the role of periodic glucose monitoring, optimal

control, the prevention of end-organ complications such as diabetic retinopathy to patients to prevent its progression. With the results from our study, we are increasing awareness of all patients attending tertiary eye clinics to the role of periodic glucose monitoring, as well as the association of higher blood glucose levels and HbA1c with diabetic retinopathy. Future studies could be done after interventions using results from this survey to determine the effectiveness of intervention.

223

224 **5. CONCLUSION**

In conclusion, the awareness between periodic blood glucose test and diabetic retinopathy is lower in Indians and those who were less educated. Participants were who aware of periodic blood glucose test were less likely to have diabetic retinopathy. Improvement to awareness levels needs to be done through continuous education and reassessment to improve the awareness in those who are not aware.

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231 **6. ACKNOWLEDGEMENTS**

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234 **7. COMPETING INTERESTS**

Authors have declared that no competing interests exist.

236

237 **8. AUTHORS' CONTRIBUTIONS**

S Sanjay carried out the conceptualization, design, execution, and editing of the manuscript.

YC Chin participated in the statistical analyses, data interpretation and writing of manuscript.

S Yan performed statistical analyses and aided in the writing of results section. EL Ong

participated in data collection. KG Au Eong carried out the editing of manuscript.

242

243 **9. CONSENT**

All authors declare that verbal informed consent was obtained from the patient at recruitment.

245

246 10. ETHICAL APPROVAL

247 All authors hereby declare that this study was approved by the appropriate ethics committee
248 and have therefore been performed in accordance with the ethical standards laid down in the
249 1964 Declaration of Helsinki.

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