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Association of Younger Age With Poor Glycemic and Cholesterol Control in Asians With Type 2 Diabetes Mellitus in Singapore

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Abstract

Background: The prevalence of type 2 diabetes mellitus (T2DM) in children and adolescents is increasing in both poor and rich countries. Epidemiologic studies have reported significant and continuous associations between HbA1c level and diabetes-related vascular complications. Younger adults with early exposure to hyperglycemia are at high risk for end-organ damage. Few studies have reported the relationship of age to glycemic control in patients with T2DM world-wide and little comparison among young adults and elderly patients especially in the Asian population. This study investigates the relationship of age and glycemic control in Asian patients with T2DM attending primary care clinics in Singapore.

Methods: We included T2DM patients who had at least 2 visits to the public-sector primary care clinic for diabetes treatment in 2009. Demographic characteristics, medical records and laboratory results were extracted from the enterprise-wide chronic disease registry. The mean HbA1c, blood pressure and LDL-cholesterol were trended by age. Multivariate logistic regression was used to identify the factors predicting "poor" glycemic control.

Results: There were 58,057 T2DM patients and both the mean HbA1c and LDL-cholesterol were lower among elderly than adult patients. Mean HbA1c was 8.08 ± 1.62% for patients < 45 years old and 6.86 ± 0.99% for patients 85+ years old. Mean LDL-cholesterol levels were 2.84 ± 0.81 and 2.55 ± 0.73 mmol/L for the respective age groups. The Malay and Indian groups had significantly poorer glycemic control compared to the Chinese, AdjOR 1.65 (95% CI: 1.54 - 1.77) and 1.50 (95% CI: 1.40 - 1.61) respectively. Other significant predictors of poor glycemic control included the male gender, presence of maculopathy or retinopathy, peripheral vascular disease, coronary heart disease, heart failure, and being on insulin therapy (AdjOR 8.00; 95% CI: 7.54 - 8.48). Patients with poor LDL-c (4.1+ mmol/L) were 4.2 times more likely to have poor glycemic control (95% CI: 3.78 - 4.66) while those with Grade 2 hypertension were 1.5 times (95% CI: 1.35 - 1.76) more likely than those without hypertension.

Conclusions: Younger T2DM patients had poorer glycemic and cholesterol control than older patients in Singapore and they should have targeted interventions to achieve "optimal" glycemic and cholesterol control.

Keywords: Glycemia; LDL-cholesterol; Control; Younger; Type 2 diabetes mellitus

Introduction

In Singapore, the prevalence of diabetes mellitus increased from 8.2% in 2004 to 11.5% in 2010 amongst its population aged between 18 and 69 years [1]. The increase in diabetes prevalence was observed across all ages, in both genders and all the major ethnic groups, especially the Malays. The prevalence estimates for 2010 (age-standardised to World Standard Population) from the International Diabetes Federation [2] indicate that Singapore's prevalence is much higher than other Asian countries such as Hong Kong (8.5%), Taiwan (7.5%), South Korea (5.3%) and Japan (5.0%), and other Western countries such as France (6.7%), Australia (5.7%) and the United Kingdom (3.6%).

Type 2 diabetes mellitus (T2DM) is no longer a disease of middle aged and older individuals [3]. Its prevalence in children and adolescents is on the increase in all countries, whether poor or rich [2]. Epidemiologic and prospective studies have reported significant and continuous associations between HbA1c level and diabetes-related vascular compli-

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cations [4-9]. Younger adults with early exposure to hyperglycemia are at high risk for end-organ damage [4-8]. As with type 1 diabetes, many children with T2DM risk developing complications at an early age, adding to a significant burden on the family and society. There is growing recognition that T2DM in the young is fast becoming a global public health issue with a potentially serious health outcome [10].

Comprehensive and appropriate management of patients with diabetes should include early screening for complications and optimize control of glucose, blood pressure and cholesterol. Very few studies have reported the relationship of age to glycemic control in patients with T2DM and the focus was largely on middle-aged and elderly patients [11]. Conclusions have been mixed, showing high prevalence of poor control in elderly, better glycemic control in older patients [12], or no effect of age on metabolic control [13]. In 2003, El-Kebbi et al studied the relationship of age to glycemic control in an African American population and showed a high prevalence of obesity and poor glycemic control in young adults compared to older patients [14]. A German study in 2009 also reported that the highest percentage of patients with inadequate glycemic control in the T2DM population is not found among the old but the 45 - 54 and 55 - 64 age groups [15].

To date, there has been little comparison of the glycemic control in young adults and elderly patients especially in the Asian population. The aim of this current study was to investigate the relationship of age to glycemic control in Asian patients with T2DM attending the public-sector primary care clinics in Singapore and identify the factors predicting poor glycemic control.

Patients and Methods

This is a retrospective study of patients attending the National Healthcare Group Polyclinics (NHGP) for the treatment of diabetes mellitus in 2009. The NHGP is a chain of 9 public sector primary care clinics providing basic comprehensive care for the population in the central and western parts of Singapore. It has an integrated electronic patient medical record which hosts both administrative and clinical information. Medical records of all patients with chronic disease conditions such as diabetes mellitus, hypertension, dyslipidemia, stroke, and coronary heart disease are linked to the enterprise-wide National Healthcare Group (NHG) Disease Management System (CDMS) [16].

Study population

We selected all the patients with existing diagnosis of T2DM from the NHG CDMS who had at least 2 attendances in the same clinic in 2009. Patients who were newly diagnosed with type 2 diabetes mellitus in 2009 or those with type 1 diabetes mellitus were excluded from the study.

Study parameters and data collection

All the demographic characteristics, medical diagnosis, clinical parameters and laboratory results were extracted directly from the NHG CDMS. Demographic characteristics included age, gender and ethnic group. Medical conditions were extracted based on ICD-9 CM diagnosis codes for hypertension, dyslipidemia, coronary heart disease, stroke, retinopathy, and peripheral vascular disease. Body Mass Index (BMI) and Glomerular Filtration Rate (GFR) were extracted and classified according to WHO guidelines.

Glycated hemoglobin (HbA1c) was the marker for measuring glycemic control. The HbA1c results in 2009 were obtained and a mean HbA1c was calculated for every patient. Glycemic control was considered "optimal" if HbA1c was ≤ 7.0%, "acceptable" if HbA1c was 7.1 - 8.0%, and "poor" if HbA1c was above 8.0%. Age was grouped into bands of 10 years for comparison of glycemic control.

Two other intermediate outcome measures were also profiled with age bands. The latest blood pressure (both systolic, SBP, and diastolic blood pressure, DBP) and LDL-cholesterol (LDL-c) levels in 2009 were recorded. BP control was considered "optimal" if SBP was ≤ 130 mmHg and DBP was ≤ 80 mmHg, "acceptable" if SBP was 131 - 139 mmHg and DBP was 81 - 89 mmHg, and "poor" if SBP was ≥ 140 mmHg and DBP was ≥ 90 mmHg. Dyslipidemia control was considered "optimal" if LDL-c was < 2.6 mmol/L, "acceptable" if LDL-c was 2.6 - 3.3 mmol/L and "poor" if LDL-c was ≥ 3.4 mmol/L.

Data analysis

Data was analyzed using PASW (version 18.0). Significance testing of proportions was carried out using Chi-square test, and of means using analysis of variance (ANOVA), where a probability (P) of less than 0.05 was considered significant. Multivariate logistic regression was used to study the factors predicting "poor" glycemic control.

This study was approved by the NHG Domain Specific Review Board.

Results

There were 58,057 patients with T2DM from 9 primary care clinics in the study. Table 1 shows that females outnumbered males by 54% : 46%. There were more males than females in the younger age groups up to 54 years and the reverse was observed from 55 years and above. Age is normally distributed (mean 64.0 ± 11.6 years), with 64% aged 60 years and older. Overall, the disproportionately higher proportion of Indians (13%) in relation to the general Singapore popu-

Table 1. Characteristics of Patients With Type 2 Diabetes Mellitus in National Healthcare Group Polyclinics in 2009

Characteristic	Age Group													
	< 45		45 - 54		55 - 64		65 - 74		75 - 84		85+		All	
	N = 2537		N = 9712		N = 18200		N = 16390		N = 9245		N = 1973		N = 58057	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Gender														
Female	1201	47	4780	49	9226	51	9047	55	5639	61	1330	67	31223	54
Male	1336	53	4932	51	8974	49	7343	45	3606	39	643	33	26834	46
Race														
Chinese	1360	54	5586	58	12670	70	12543	77	7343	79	1702	86	41204	71
Indian	574	23	1823	19	2471	14	1655	10	847	9	115	6	7485	13
Malay	475	19	1880	19	2488	14	1726	11	790	9	100	5	7459	13
Others	128	5	423	4	571	3	466	3	265	3	56	3	1909	3
Other medical problems														
Hypertension	1344	53	6707	69	14992	82	14836	91	8732	94	1872	95	48483	84
Dyslipidemia	2409	95	9484	98	17878	98	16152	99	9102	98	1902	96	56927	98
Coronary Heart Disease / Heart Failure	123	5	1008	10	2975	16	3998	24	3147	34	799	40	12050	21
Stroke	48	2	462	5	1423	8	2131	13	1785	19	512	26	6361	11
Maculopathy/Retinopathy	149	6	869	9	1820	10	1579	10	874	9	152	8	5443	9
Peripheral Vascular Disease	41	2	253	3	579	3	709	4	584	6	155	8	2321	4

Table 1. Characteristics of Patients With Type 2 Diabetes Mellitus in National Healthcare Group Polyclinics in 2009 (Cont'd)

Characteristic	Age Group													
	< 45		45 - 54		55 - 64		65 - 74		75 - 84		85+		All	
	N = 2537		N = 9712		N = 18200		N = 16390		N = 9245		N = 1973		N = 58057	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Body Mass Index (BMI)														
Underweight	20	1	59	1	184	1	299	2	266	3	80	4	908	2
Normal	416	16	2154	22	5265	29	5738	35	3245	35	592	30	17410	30
Obese I	453	18	1537	16	2130	12	1343	8	534	6	58	3	6055	10
Obese II	275	11	661	7	702	4	327	2	137	1	17	1	2119	4
Overweight	745	29	3155	32	6002	33	4658	28	2228	24	289	15	17077	29
Missing	628	25	2146	22	3917	22	4025	25	2835	31	937	47	14488	25
Chronic Kidney Disease														
Stage 1	1511	60	4574	47	5698	31	3046	19	919	10	116	6	15864	27
Stage 2	499	20	3208	33	7697	42	7290	44	3499	38	566	29	22759	39
Stage 3	60	2	523	5	2234	12	3814	23	3294	36	770	39	10695	18
Stage 4	6	0	60	1	232	1	437	3	425	5	160	8	1320	2
Stage 5	3	0	28	0	71	0	84	1	54	1	22	1	262	0
Missing	458	18	1319	14	2268	12	1719	10	1054	11	339	17	7157	12

Table 2. Mean HbA1c, LDL-c, Serum Creatinine and Blood Pressure by Age Group

Parameter	Unit	Age Group											
		< 45		45 - 54		55 - 64		65 - 74		75 - 84		85+		All	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HbA1c	%	8.08	1.62	7.88	1.49	7.52	1.26	7.20	1.05	7.03	1.01	6.86	0.99	7.42	1.27
LDL-cholesterol	mmol/L	2.84	0.81	2.79	0.76	2.68	0.72	2.58	0.68	2.56	0.70	2.55	0.73	2.65	0.72
Serum creatinine	mmol/L	69.42	36.39	75.16	42.91	81.93	44.02	90.83	50.75	98.52	49.87	108.24	62.68	86.38	48.12
Systolic BP	mmHg	124.31	12.23	127.41	12.92	130.62	46.66	132.33	13.58	134.23	55.43	132.57	14.94	130.93	35.64
Diastolic BP	mmHg	76.25	7.57	76.10	7.67	74.40	7.72	71.90	7.78	69.92	8.10	68.70	8.24	73.17	8.12

HbA1c: Glycated hemoglobin; LDL: Low-density lipoprotein; BP: Blood pressure

lation reflected the higher incidence of diabetes mellitus in this ethnic group. The Indians and Malays made up 23% and 19% respectively among those below 45 years old, declining to below 10% for patients 75 years and above.

Other medical conditions

The prevalence of hypertension and dyslipidemia among these T2DM patients were 84% and 98% respectively. The prevalence of hypertension increased with age from 53% (below 45 years) to above 90% (65 years and above). The prevalence of dyslipidemia was high for all age groups, ranging from 95% to 99%.

The prevalence of vascular disease conditions increased with age. About 1 in 4 patients were also treated for coronary heart disease (range 5% to 40%), 11% had history of a cerebrovascular event (range 2% to 26%), 9% had retinopathy (range 6% to 10%) and 4% had peripheral vascular disease (2% to 8%). The proportion of patients with Chronic Kidney Disease (CKD) stages 1 and 2 decreased with age (Table 1).

BMI distribution

Mean BMI was 26.3 ± 4.7 kg/m^2. There were more patients being overweight or obese among the younger age groups compared to older age groups (Table 1). About 1% to 4% was underweight, with increasing prevalence among the old age groups. A larger proportion of the older patients, especially those 85 years and older, did not have a weight measurement within the year.

Glycemic control

Mean HbA1c decreased with age, from 8.08 ± 1.62% for those below 45 years to less than 7% for those 85 years and above (Table 2). The distribution of HbA1c across the age groups is shown in Figure 1. The proportion of patients in each age group with HbA1c > 8% reduced with age, from 40% (below 45 years) to 10% (85 years and above).

Blood pressure control

The mean blood pressure was 131/73 mmHg (Table 2). When comparing across the age groups, the proportion with "normal" and "high normal" blood pressure control reduced with age from 71.2% (below 45 years) to 55% (85 years and older).

LDL-cholesterol (LDL-c) control

Similar to HbA1c, the mean LDL-c decreased with age, from 2.84 ± 0.81 mmol/L (below 45 years) to 2.55 ± 0.73 mmol/L (85 years and older). Proportion with "optimal" LDL-c control increased from 42% (below 45 years) to 57% (85 years

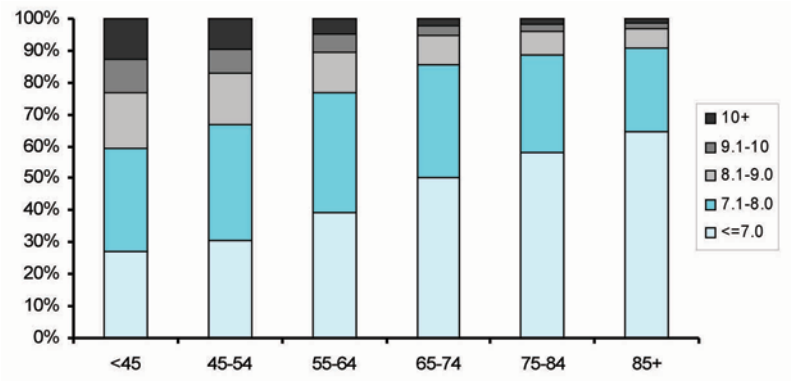

Figure 1. Distribution of mean HbA1c (%) by age group.

and above) (Fig. 2).

Management of diabetes mellitus

The average number of physician clinic visits per year for diabetes care increased with HbA1c level, from 4.1 (for patients with HbA1c below 7%) to 5.2 (for patients with HbA1c 9 - 10%) and 4.9 (for patients with HbA1c above 10%). The proportion of patients who visited a Care Manager at least once in the year also increased with HbA1c, from 6.8% (HbA1c below 7%) to 52% (HbA1c above 9%). Similarly, percentage of patients with visits to the Dietitian increased from 1.3% (HbA1c below 7%) to 10% (HbA1c above 9%).

The proportion of patients in each age group treated with insulin ranged from 6.2% to 15.4% and was associated with the degree of glycemic control, increasing from 30.3% (for patients with mean HbA1c 8.1 to 9.0%) to 45.5% (for patients with mean HbA1c above 10%).

Multivariate logistic regression analysis

Table 3 shows the results of the multivariate logistic regression to predict "poor" HbA1c level above 8%. Compared to the group 85 years and above, those below 75 years old were significantly more likely to have "poor" HbA1c control. The adjusted OR for < 45 years was the highest (4.21; 95% CI: 3.38 - 5.26), followed by 45 - 54 years (3.24; 95% CI: 2.64 - 3.97), 55 - 64 years (2.12; 95% CI: 1.74 - 2.59) and 65 - 74 years (1.31; 95% CI: 1.07 - 1.59). Male patients had an adjusted OR 1.21 (95% CI: 1.15 - 1.27) over the female patients. The Malay and Indian groups had significantly poorer glycemic control compared to the Chinese, with adjusted OR of 1.65 (95% CI: 1.54 - 1.77) and 1.50 (95% CI: 1.40 - 1.61) respectively.

Patients with known cardiovascular complications had higher odds of "poor" glycemic control than those without maculopathy or retinopathy, peripheral vascular disease, coronary heart disease or heart failure (Table 3). Patients who were treated with insulin were 8.19 (95% CI: 7.70 - 8.73) times the odds for having "poor" glycemic control than those on oral hypoglycemic agents only. Those with "poor" glycemic control also had correspondingly poorer LDL-c and blood pressure control. Compared to patients with "optimal" LDL-c < 2.6 mmol/L, the adjusted OR for "poor" glycemic control increased with poorer LDL-c control, from 1.42

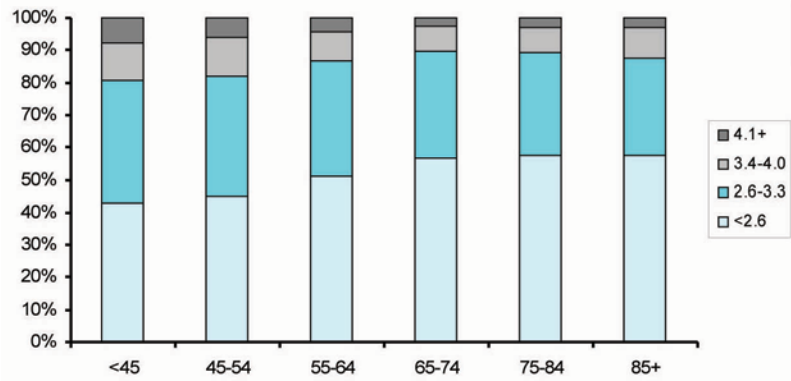

Figure 2. Distribution of mean LDL-cholesterol (mmol/L) by age group.

Table 3. Logistic Regression for Factors Significantly* Associated With "Poor" Glycemic Control

Variable	"Poor" glycemic control (HbA1c > 8%)			
	Unadjusted OR	95% CI	Adjusted OR	95% CI
Age, y				
< 45	6.67*	5.61 - 7.94	4.21*	3.38 - 5.26
45 - 54	4.88*	4.16 - 5.73	3.24*	2.64 - 3.97
55 - 64	2.99*	2.55 - 3.50	2.12*	1.74 - 2.59
65 - 74	1.65*	1.41 - 1.94	1.31*	1.07 - 1.59
75 - 84	1.28*	1.08 - 1.51	1.12	0.91 - 1.37
[85+]	1		1	
Gender				
Male	1.14*	1.09 - 1.20	1.21*	1.15 - 1.27
[Female]	1		1	
Race				
[Chinese]	1		1	
Malay	2.12*	2.01 - 2.24	1.65*	1.54 - 1.77
Indian	2.05*	1.94 - 2.17	1.50*	1.40 - 1.61
Others	1.59*	1.43 - 1.77	1.31*	1.15 - 1.49
Other Medical Conditions				
Maculopathy/Retinopathy (Yes)	2.14*	2.01 - 2.27	1.47*	1.36 - 1.59
[No]	1		1	
Peripheral vascular disease (Yes)	1.77*	1.61 - 1.93	1.27*	1.12 - 1.43
[No]	1		1	
Coronary heart disease (Yes)	0.99	0.95 - 1.05	1.15*	1.08 - 1.23
[No]	1		1	
Heart failure (Yes)	1.39*	1.24 - 1.54	1.46*	1.27 - 1.68
[No]	1		1	
Ischemic stroke (Yes)	0.97	0.87 - 1.10	1.22*	1.06 - 1.40
[No]	1		1	
Stage of chronic kidney disease				
[Stage 1]	1		1	
Stage 2	0.54*	0.52 - 0.57	0.63*	0.60 - 0.67
Stage 3	0.61*	0.57 - 0.65	0.69*	0.64 - 0.75
Stage 4	0.99	0.87 - 1.12	0.75*	0.64 - 0.88
Stage 5	0.81	0.60 - 1.09	0.32*	0.22 - 0.47

[ ] depicts reference group; Adj OR: adjusted odds ratio; CI: confidence interval; NS: not significant
* P < 0.05 by stepwise logistic regression analysis

Table 3. Logistic Regression for Factors Significantly* Associated With "Poor" Glycemic Control (Cont'd)

Variable	"Poor" glycemic control (HbA1c > 8%)			
	Unadjusted OR	95% CI	Adjusted OR	95% CI
Diabetes Treatment and Control of Risk Factors				
Insulin (Yes)	8.09*	7.67 - 8.53	8.19*	7.70 - 8.73
[No]	1		1	
LDL-c control, mmol/L				
[< 2.6]	1		1	
2.6 - 3.3	1.33*	1.26 - 1.39	1.42*	1.34 - 1.50
3.4 - 4.0	2.22*	2.07 - 2.39	2.42*	2.24 - 2.62
4.1+	4.20*	3.83 - 4.62	4.30*	3.87 - 4.78
Blood pressure control				
[Normal]	1		1	
High Normal	1.06	1.00 - 1.11	1.10*	1.04 - 1.17
Grade 1 Hypertension	1.06	1.00 - 1.13	1.20*	1.12 - 1.70
Grade 2 Hypertension	1.27*	1.13 - 1.43	1.47*	1.27 - 1.70
Body Mass Index (BMI)				
Underweight	0.80*	0.66 - 0.95	1.24	0.99 - 1.54
[Normal]	1		1	
Overweight	1.26	1.19 - 1.32	1.31*	1.15 - 1.49
Obese Class 1	1.63*	1.52 - 1.74	1.29*	1.20 - 1.39
Obese Class 2	1.94*	1.75 - 2.14	1.39*	1.27 - 1.53

[ ] depicts reference group; Adj OR: adjusted odds ratio; CI: confidence interval; * P < 0.05 by stepwise logistic regression analysis

(1.34 - 1.50) for group with LDL-c 2.6 - 3.3 mmol/L to 4.30 (3.87 - 4.78) for the group with LDL-c above 4.1 mmol/L. Similarly, compared to those with normal blood pressure, adjusted OR for "poor" glycemic control among grade 1 hypertension was 1.20 (1.12 - 1.70) and grade 2 hypertension was 1.47 (1.27 - 1.70).

Discussion

A few studies described the relationship of age to glycemic control in patients with diabetes [12, 13, 17]. In the Strong Heart Study among native Americans, age was found to be inversely related to HbA1c level [12]. There was no change in the median HbA1c level at baseline (1989 - 1992) and follow-up (1994 - 1995) surveys. The NHANES III (1988 - 1994) also reported that younger patients were more likely to have an elevated HbA1c level, although there was no significant association between age and HbA1c levels in a predominantly white population [13]. In an Australian study, Bruce et al also reported that age was inversely associated with glycemic control whereas duration of diabetes and treatment with either oral hypoglycemic agents or insulin were positively associated with glycemic control [18]. It was noted that octogenarians in Australia differed significantly from younger age groups, those with longer diabetes duration did not demonstrate the increase in hyperglycemia seen in other age groups. A significantly greater proportion of the oldest diabetic subjects had satisfactory HbA1c levels compared with younger subjects.

The Diabcare-Asia project from Singapore, India and Taiwan had earlier reported that one-third to one-half of the diabetic population had poor glycemic control and suboptimal lipid control [19-21]. Our study also supports that, in a predominantly Asian patient population attending primary care clinics, the younger patients had poorer HbA1c and LDL-c control than older patients. The prevalence of hypertension and dyslipidemia were high across all ages and

higher than the prevalence in the general population. As expected, the prevalence of vascular complications such as coronary heart disease and cerebrovascular disease increased with age and were higher than the general population without diabetes mellitus [22-25].

Studies have suggested that early onset T2DM was associated with an increased risk for complications compared with later onset diabetes [26] and that the development and progression of complications might be more rapid in early onset disease [27-29]. Song et al in 2009 reported that the management of risk factors for diabetes complications was inadequate among the early onset T2DM cohort and they were at substantial risk of developing diabetes complications in later years and at an earlier stage [30]. Our study also showed that the poor glycemic control among the younger T2DM patients was associated with poorer cholesterol and blood pressure control. These younger patients have a higher lifetime risk of developing micro- and macro-vascular complications and should be treated much more aggressively to achieve "optimal" glycemic, blood pressure and cholesterol control [7, 9, 22, 31-36].

It is not fully understood why younger patients have worse glycemic control than older patients. In Singapore, all citizens regardless of age have equal access to medical care provided by the public sector. The older patients may be more motivated to take care of their diabetes and are more compliant with their medication and eat healthy low-fat diet [37]. On the other hand, younger patients might be more likely to disregard diabetes as being important and be less adherent to medication, lifestyle and diet restrictions. Similar findings were reported by El-Kebbi in 2003 that the persistence of HbA1c elevation in younger individuals could be due to inadequately low medication dosage or infrequent use of combination drug regimens [14]. The younger patient also tends to be more obese than older patients with resultant higher insulin resistance and may need more aggressive therapy to achieve glycemic control. In addition to treating raised HbA1c, physicians should be alerted to commence or reinforce aggressive lifestyle intervention, lipid-lowering and anti-hypertensive therapy especially for the younger T2DM patients.

This study also showed that patients with "optimal" glycemic control had fewer visits to the clinic annually for the treatment of diabetes. Those with "poor" glycemic control were more likely to have visited a Care Manager and Dietitian for general self-management tips, health information and dietary advice on diabetes. The overall healthcare utilization and expenditure would be correspondingly higher for patients with poorer glycemic control. Wagner showed that a sustained reduction in HbA1c level among adult diabetic patients is associated with significant cost savings within 1 to 2 years of improvement [38].

There are several limitations in this study. As data was drawn from the Diabetes Registry, we were unable to collect data to adjust for the duration of diabetes mellitus which may be associated with progressive impairment of insulin secretion. There was also no data on physical activity and adherence of diet and lifestyle. Some patients, especially the older ones, did not have BMI measurement.

Nonetheless, this study of an Asian population with diabetes mellitus has provided an insight into the variation of glycemic and cholesterol control with age. We analyzed the data of a large captive population from the Diabetes Registry and we were able to study the prevalence of hypertension, dyslipidemia and other vascular complications in patients with T2DM. All laboratory results were captured directly and were accurate and complete. The mean HbA1c for the year was calculated for every patient to reflect the average glycemic control over a year instead of using a single HbA1c reading.

Younger diabetics are at higher cumulative risk to develop vascular-related complications over time. The reasons for poor glycemic and cholesterol control are not well understood and are likely to be multifactoral. Future research could study patient's health literacy and their understanding of diabetes, health-seeking and treatment-adherence behavior across the ages.

This study shows that younger patients with T2DM had poorer glycemic and cholesterol control than older patients in Singapore. Those with poor glycemic control also had corresponding poorer cholesterol and blood pressure control. These patients had a higher lifetime risk of developing micro- and macro-vascular complications and more research should be done to investigate reasons for the poorer control so that targeted interventions can be designed for them.

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The authors declare that they have no relevant financial interests in this manuscript.

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