Original Article

Incidence and risk factors for diabetic retinopathy in the communities of Shenzhen

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Background: To understand the prevalence of diabetic retinopathy (DR) in Shenzhen and to analyze the risk factors for the occurrence and development of DR. Based on the comprehensive information system for diabetes prevention and control in the communities of Shenzhen in 2019, six community health service centers in Shenzhen were used as research sites to carry out multicenter, cross-sectional screening studies.

Methods: Cluster random sampling was used to collect data from 904 patients with diabetes in Shenzhen. The occurrence of DR and vision-threatening diabetic retinopathy (VTDR) was analyzed, and multivariate logistic regression was performed to analyze the risk factors for DR and VTDR. EpiData version 3.1 (EpiData Association, Odense, Denmark) statistical software was used to build a database, and Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, N.Y., USA) was used to sort up and analyze the data.

Results: The prevalence of DR among diabetic patients in Shenzhen was 18.58% [95% confidence interval (CI): 16.13–21.3%], and the prevalence of VTDR was 2.43% (95% CI: 1.57–1.2%). The prevalence of DR and VTDR was higher in males than in females. Logistic regression analysis showed that age, disease duration, medication mode, and the occurrence of diabetic peripheral neuropathy (DPN) were associated with the incidence of DR in diabetic patients, and that disease duration, the occurrence of DPN, and diabetic nephropathy were associated with the occurrence of VTDR.

Conclusions: The prevalence of DR in the communities of Shenzhen is high. Age, disease duration, medications, and DPN are the major risk factors for the occurrence of DR.

Keywords: Diabetic retinopathy (DR); vision-threatening diabetic retinopathy (VTDR); community screening; risk factors

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Introduction

Over the past 30 years, the prevalence of diabetes in China has rapidly increased, and the incidence of diabetic retinopathy (DR) has also gradually increased (1). In 2012, a meta-analysis based on 35 epidemiological studies worldwide showed that 34.6% of diabetic patients had DR and that 10.2% of diabetic patients had vision-threatening DR (VTDR). That is, there are approximately 93 million DR and VTDR patients worldwide, resulting in tremendous public health issues globally (2,3). Recently, epidemiological studies have been conducted on

the prevalence of, risk factors for, and progression of DR in countries such as the United States (4), England (5-7), China (8,9), Portugal (10) and so on (11,12). In 1998, Shenzhen initiated comprehensive prevention and treatment work for hypertension and diabetes in the community, emerging as the first group of cities in China to become a "National Demonstration Site for Comprehensive Prevention and Control of Chronic Diseases" and a "Demonstration City of Comprehensive Prevention and Control of Chronic Diseases in Guangdong Province". However, at this stage, each community health service center lacks disease management for DR patients. The present research relies on community diabetes management in Shenzhen to understand the prevalence of DR and to analyze its influencing factors through community screening. This study aims to provide a basis for improving the intervention management of DR in communities in China.

We present the following article in accordance with the MDAR checklist (available at http://dx.doi.org/10.21037/apm-20-2526).

Methods

Based on the comprehensive information system for diabetes prevention and control in the communities of Shenzhen in 2019, six community health service centers in Shenzhen were used as research sites to carry out multicenter, cross-sectional screening studies.

Study subjects

In this study, we conducted a survey using cluster random sampling and used type II diabetic patients registered at the Shenzhen Community Health Service Center as study subjects. The inclusion criteria for study subjects were as follows: (I) diabetic patients aged over 20 years; and (II) healthy patients who could receive routine DR screening. Patients were excluded based on the following criteria: (I) patients with ketoacidosis, hyperosmolar diabetic acidosis, or other serious diseases; (II) patients with mental illness or severe cognitive impairment; (III) patients who were pregnant during the study; and (IV) patients who were from the town and unwilling to participate. This study was approved by the Ethics Committee of Shenzhen Eye Hospital (No. 2017041201), and informed consent was obtained from all diabetic patients who participated in the screening. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Sampling method

At present, the prevalence rate of DR in the Chinese diabetic population is 25–35%, and the prevalence rate of DR in the diabetic population of Shenzhen is approximately 25%. According to the random sampling formula n = (Z 1-a/2/δ) 2 p (1-p) (allowable error, 4%; α=0.05), n was approximately 550. Considering the errors caused by cluster sampling, approximately 825 diabetic patients were required, thereby increasing the calculated sample size (n) by 50%. This study expanded the sample size of diabetic patients to 1,000 based on a compliance rate of 80%. Finally, the data of 904 diabetic patients were collected, and the recovery rate was 90.4%.

Survey method

Appointments for diabetic patients

Diabetic patients' information was obtained through the community comprehensive prevention and treatment information system for diabetic patients in Shenzhen. Diabetic patients were regularly scheduled (via text message or telephone conversation) to attend the community health center (where health records are located) for free retinal screening.

Questionnaire

Relevant personnel were trained to administer the self-made "Shenzhen Diabetic Retinopathy Screening Questionnaire" in face-to-face interviews. The general information included patient's sex, age, education level, occupation, smoking and drinking history, exercise history, diet, family history of diabetes, duration of diabetes, medication status, and disease history, among other information.

Fundus examinations

In the community health service center, a trained general practitioner performed fundus examinations using a hand-held ophthalmoscope to observe the general conditions of the anterior segment of the eye. Shenzhen Eye Hospital has been regularly sitting in many social health centers in the city to coach general practitioners for fundus examination and fundus photography training for 5 years before. Before the formal start of the project, the ophthalmologists in the members of our group have again trained and assessed the general practitioners of the social health center selected in the project. The ophthalmologist of our hospital carries on the remote interpretation to the fundus photography image data and the comprehensive diagnosis analysis to each screening patient all screening data. Patients with DR were preliminarily selected.

Table 1 Basic information of the study subjects

Variables	NDR (case)	%	DR (case)	%	Total (case)	%
Sex (case)						
Male	403	54.76	93	55.36	496	54.87
Female	333	45.24	75	44.64	408	45.13
Age (years)						
<60	272	36.96	42	25	314	34.73
≥60	464	63.04	126	75	590	65.27
Ethnicity						
Han	734	99.73	167	99.4	901	99.67
Minority	2	0.27	1	0.6	3	0.33
Education level						
Elementary	80	10.87	18	10.71	98	10.84
Middle school	151	20.52	35	20.83	186	20.58
High school	238	32.34	57	33.93	295	32.63
Bachelor's degree or higher	240	32.61	46	27.38	286	31.64
Unspecified	27	3.67	12	7.14	39	4.31
Health insurance						
No insurance	137	18.61	48	28.57	185	20.46
Basic health insurance	599	81.39	120	71.43	719	79.54
Total	736	81.42	168	18.58	904	100.00

NDR, non-diabetic retinopathy; DR, diabetic retinopathy.

High-risk DR patients were informed and transferred to Shenzhen Eye Hospital, where a digital retinal exam without dilation was conducted. Two 35-degree fundus posterior pole images were taken, and fundus fluorescein angiography was performed. Disease stage (stages 0–IV) was determined in accordance with 2003 International Classification of DR (13). based on the diagnosis results. VTDR includes severe non proliferative DR (NPDR), proliferative DR (PDR), and clinically significant macular edema (14).

Statistical analysis

EpiData version 3.1 (EpiData Association, Odense, Denmark) statistical software was used to build a database, and Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, N.Y., USA) was used to sort up and analyze the data. Measurement data with a normal distribution were presented as the mean ± standard deviation (SD). A t test or analysis of variance (ANOVA) was used for intergroup comparisons. Count data were presented as relative numbers, and the chi-square test was used for intergroup comparisons. Multivariate logistic regression analysis was performed to identify risk factors. The results were expressed as odds ratio (OR) [95% confidence interval (CI)]. α=0.05 was used as the threshold for significance for all statistical tests.

Results

Basic information

A total of 904 patients [496 males (54.87%) and 408 females (45.13%)] were enrolled in this study, including 736 non-diabetic retinopathy (NDR) patients (81.42%) and 168 DR patients (18.58%). The average age of the patients was 63.07±11.28 years (*Table 1*).

Prevalence of DR

Of the 904 diabetic patients enrolled in this study, 168 were DR patients (112 patients with mild NPDR, 34 patients with moderate PDR, 17 patients with severe PDR, five patients with PDR, and 22 patients with VTDR). Among the DR patients, 93 were male (55.36%), and 75 were female (44.64%), with an average age of 65.13±9.73 years. The prevalence of DR was 18.58% (95% CI: 16.13–21.3%), of which, the prevalence rates for NPDR, PDR, and VTDR were 18.03% (95% CI: 15.611–2.73%), 0.55% (95% CI: 0.2–1.36%), and 2.43% (95% CI: 1.57–3.72%), respectively. The prevalence of DR was higher in males than in females.

Differential analysis of risk factors for DR and VTDR

Differential analysis of the risk factors for DR and VTDR was performed in terms of biological factors, disease history, and behavioral factors. The prevalence of DR was significantly higher in patients with the following characteristics: age ≥60 years, longer disease duration, the use of hypoglycemic drugs (HDs), diabetic foot, and diabetic peripheral neuropathy (DPN) (P<0.05, *Table 2*). The prevalence of VTDR was markedly higher in patients with the following characteristics: longer disease duration, HDs, DPN, and diabetic nephropathy (P<0.05). Because of the limited number of cases collected by this epidemiological study and limited by project funds, we can't draw the conclusion that a significant increase in the prevalence also indicate an increase in the prevalence of severe PDR.

Multivariate logistic regression analysis

Dimensional indices, such as demographic characteristics, biological indicators, disease history, and behavioral factors, were used as independent variables, while DR or VTDR were used as the dependent variables. P<0.05 was used as the inclusion criterion and P>0.1 was used as the exclusion criterion. Multivariate logistic stepwise regression analysis was performed. The results indicated that the risk factors for DR included the type of health insurance (OR =0.637; basic health insurance *vs*. no insurance; P=0.028), duration of diabetes (OR =2.324; ≥15 *vs*. <5 years; P=0.001), medication (OR =6.070; HD + insulin *vs*. no medication, diet + exercise; P=0.001/OR =3.334; oral HD administration only *vs*. no medication, diet + exercise; P=0.011), and DPN (OR =3.042; with DPN *vs*. without DPN; P=0.004) (*Table 3*). The risk factors for VTDR included duration of diabetes (OR =23.645; ≥15 *vs*. <5 years; P=0.003), DPN (OR =7.100; with DPN *vs*. without DPN; P=0.001), and diabetic nephropathy (OR =12.674; with *vs*. without; P=0.006) (*Table 3*).

Discussion

This study showed that the prevalence of DR among diabetic patients in the communities of Shenzhen was 18.58% (95% CI: 16.13–21.3%) and that the prevalence of VTDR was 2.43% (95% CI: 1.57–1.2%). Pan *et al*. investigated the prevalence of DR among diabetic patients in the communities of Suzhou and reported a prevalence rate of 18.00% (95% CI: 15.50–20.60%) (14). The lifestyle can significantly reduce the prevalence of VTDR including pay attention to standardized management of blood glucose, control blood glucose level well, exercise regularly, regulate diet, quit smoking and alcohol. Song *et al*. conducted a meta-analysis in 2018, based on 31 published studies, on the prevalence of DR among the diabetic population and identified a prevalence rate of 18.45% (95% CI: 14.77–22.43%) (15). Our findings are consistent with the results of the aforementioned studies. However, our results were slightly lower than those reported by Xu *et al*. (prevalence rate of 24.70%; 95% CI: 22.80–26.60%), who conducted a study of the current situation among diabetic patients in the communities of Beijing (16), and were also lower than the findings of Varma *et al*.'s study of Chinese Americans (prevalence rate of 35.80%, 95% CI: 32.10–39.60%) (17). In our study, the prevalence rate for VTDR was lower than that reported by Pan *et al*. (4.40%, 95% CI: 3.10–5.80%) (14), which may be related to lifestyle differences and the age of the study population.

This study also showed that the risk factors for DR development among diabetic patients in the communities of Shenzhen were disease duration, type of health insurance, medication, and DPN, while the risk factors associated with VTDR were disease duration, DPN, and diabetic nephropathy. Other risk factors (such as elevated glycated hemoglobin levels, smoking, drinking, BMI, and dyslipidemia) reported in previous studies were not found to be associated with DR or VTDR in our study.

The duration of diabetes in the DR group was longer than that in the NDR group, and the prevalence of DR was 1.324 times higher in diabetic patients with a disease duration of more than 15 years compared to patients with a disease duration of less than 5 years. This is consistent with the results reported by Dutra *et al*. (prevalence of DR was 1.07 times higher in patients with a disease duration of diabetes more than 15 years compared to patients with

Table 2 Differential analysis of risk factors for DR and VTDR in diabetic patients

Indicator	DR				VTDR			
	NDR	DR	χ^2 value	P value	NVTDR	VTDR	χ^2 value	P value
Biological indicators								
Age (years)			8.625	0.003*			0.554	0.457
<60	272	42			308	6		
≥60	464	126			574	16		
Sex (case)			0.02	0.888			0.216	0.642
Male	403	93			485	11		
Female	333	75			397	11		
Body mass index (BMI, kg/m^2)			1.958	0.162			1.048	0.306
<24	381	97			464	14		
≥24	355	71			418	8		
SBP (mmHg)			0.186	0.666			2.805	0.094
<140	653	151			782	22		
≥140	83	17			100	0		
DBP (mmHg)			0.237	0.626			2.035	0.154
<90	711	161			852	20		
≥90	25	7			30	2		
Fasting blood glucose (mmol/L)			1.271	0.53			0.922	0.631
<6.1	168	40			203	5		
≥6.1	389	94			473	10		
Unclear	179	34			206	7		
Diseases history								
Duration of diabetes (years)			25.994	<0.001*			30.451	<0.001*
<5	243	35			277	1		
5–14	360	74			428	6		
≥15	133	59			177	15		
History of hypertension			0.14	0.709			0.727	0.394
No	371	82			440	13		
Yes	365	86			442	9		
History of hyperlipemia			0.003	0.957			1.971	0.16
No	501	114			597	18		
Yes	235	54			285	4		
History of coronary heart disease			0.067	0.795			0	0.991
No	634	146			761	19		
Yes	102	22			121	3		

Table 2 (*continued*)

Table 2 (*continued*)

Indicator	DR				VTDR			
	NDR	DR	χ^2 value	P value	NVTDR	VTDR	χ^2 value	P value
History of cerebral infarction			0.355	0.551			0.001	0.978
No	702	162			843	21		
Yes	34	6			39	1		
Diabetic foot			7.027	0.030*			2.323	0.313
No	516	104			608	12		
Yes	12	7			18	1		
Unclear	208	57			256	9		
DPN			19.953	<0.001*			24.806	<0.001*
No	499	94			584	9		
Yes	18	15			28	5		
Unclear	219	59			270	8		
Diabetic nephropathy			0.001	0.972			11.631	0.001*
No	727	166			873	20		
Yes	9	2			9	2		
Behavioral factors								
Medication								
Diet + exercise	85	5			89	1		
Insulin injection only	44	10	28.595	<0.001*	50	4	9.851	0.020*
Oral HD only	540	117			645	12		
HD and insulin	67	36			98	5		
Smoking status			0.121	0.728			2.303	0.129
No smoking	614	142			735	21		
Smoking	122	26			147	1		
Drinking status			2.064	0.151			0.908	0.341
No drinking	544	115			641	18		
Drinking	192	53			241	4		

* indicate the difference is significant. DR, diabetic retinopathy; VTDR, vision-threatening diabetic retinopathy; NDR, non-diabetic retinopathy; NVTDR, non-vision-threatening diabetic retinopathy.

a duration of diabetes less than 5 years) (18), and with those reported by Wat *et al*. and Raum *et al*. (19,20). These findings are related to ocular fundus lesions caused by poor glycemic control. Diabetic patients usually have poor glycemic control, and thus, the longer the duration of diabetes, the more severe the damage to the structure and function of the ocular fundus, and the higher the prevalence of DR. The prevalence of DR and VTDR was higher in cases complicated by DPN, suggesting that diabetes damages the health of both large and small blood vessels. Although risk factors such as duration of diabetes, DPN, and diabetic nephropathy cannot be changed, these risk factors can help to determine the extent of screening for patients with DR. Individualized screening intervals for

Table 3 Multivariate logistic regression analysis of retinopathy in diabetic patients in Shenzhen

Indicator	B	SE	Wald	Sig	Exp (B)	95% CI
DR						
Constant	2.389	0.614				
Type of health insurance (control group: no insurance)						
Basic health insurance	–0.451	0.205	4.848	0.028*	0.637	0.426–0.952
Course of disease (control group: <5 years)						
5–14 years	0.276	0.226	1.49	0.222	1.318	0.846–2.053
≥15 years	0.843	0.256	10.838	0.001*	2.324	1.407–3.841
Treatment measures (control group: diet + exercise)						
HD + insulin	1.803	0.519	12.078	0.001*	6.07	2.195–16.785
Inject insulin only	0.939	0.595	2.492	0.114	2.559	0.797–8.215
Oral HD only	1.204	0.476	6.388	0.011*	3.334	1.31–8.484
DPN (control group: without DPN)						
With DPN	1.113	0.386	8.322	0.004*	3.042	1.429–6.479
Unclear	0.323	0.191	2.843	0.092	1.381	0.949–2.01
VTDR						
Constant	–6.217	1.079				
Course of disease (control group: <5 years)						
5–14 years	1.587	1.116	2.023	0.155	4.89	0.549–43.583
≥15 years	3.163	1.071	8.725	0.003*	23.645	2.899–192.874
DPN (control group: without DPN)						
With DPN	1.96	0.617	10.083	0.001*	7.1	2.118–23.809
Unclear	0.537	0.509	1.112	0.292	1.711	0.631–4.638
Diabetic nephropathy (control group: without diabetic nephropathy)						
With diabetic nephropathy	2.54	0.931	7.441	0.006*	12.674	2.044–78.595

* indicate the difference is significant. DR, diabetic retinopathy; HD, hypoglycemic drug; DPN, diabetic peripheral neuropathy; VTDR, vision-threatening diabetic retinopathy; SE, standard error; Sig, significance; Exp, exponential.

diabetic patients based on risk has been shown to be cost-effective (21). and can help to reduce the economic burden of fundus screening. We can use the database to develop deep learning or artificial intelligence model and predict the risk of DR progress. On this basis, personalized screening and intervention can be exerted.

Diabetes medication had a greater impact on the prevalence of DR than the other factors, and diabetic patients treated only with diet and exercise had the lowest prevalence of DR. The regression analysis showed that, compared to patients treated only with diet and exercise (i.e., no medication), the prevalence of DR was 6.07 times higher (P=0.001) in those treated with HDs plus insulin, and 3.334 times higher (P=0.011) in those treated with oral HDs only. The prevalence of DR was not significantly different between patients treated with insulin injections only and those treated with diet and exercise only. However, Song *et al*.'s meta-analysis showed that the prevalence of DR was higher in insulin-treated patients than in noninsulin-treated patients (OR =1.99, 95% CI: 1.34–2.95) (15), and Kumari *et al*. and Zhao *et al*. also reported a higher prevalence of DR in insulin-treated patients (17,22,23). A growing number

of studies have also shown that hypoglycemics including incretins, such as glucagon-like peptide-1 receptor agonists (GLP-1) and sodium/glucose cotransporter-2 inhibitors (SGLT2i), are associated with the suppression of DR occurrence and progression (24,25). Therefore, differences in DR prevention using specific therapeutic measures should be further validated in cohort studies and controlled clinical trials.

In addition, the analysis showed that the incidence of DR in diabetic patients covered with basic health insurance was lower than that of diabetic patients without health insurance, highlighting the reducing effect of basic health insurance policies on the occurrence of DR. These findings suggest that Chinese policy makers should further increase or improve basic health insurance coverage and guarantees, and that standardized and reasonable chronic disease management and guidance should be given to diabetic patients.

The present study has some limitations that should be noted. This is a cross-sectional study, and therefore, the causal relationship between risk factors and DR cannot be analyzed. A case-control or cohort study should be carried out for further analysis. Also, the limited variety of clinical biological indicators in diabetic patients may affect the determination of relevant risk factors. Other risk factors (such as elevated glycated hemoglobin levels, smoking, drinking, BMI, and dyslipidemia) reported in previous studies were not found to be associated with DR or VTDR in our study. Because of the limited number of cases collected by this epidemiological study and incomplete data on patients provided by the Centre, we can't analyze the relevant factors, which is the next step we need to do. Therefore, future community surveys should further expand the relevant biological indicators to obtain more comprehensive conclusions.

Conclusions

This study investigated the current status of the occurrence of retinopathy and related risk factors in diabetic patients in the communities of Shenzhen in the southern part of China. The results showed that the occurrence of retinopathy in diabetic patients in the southern part of China is high, which is consistent with that in the eastern part of China. The potential reasons are that on the one hand, the prevalence of DM is high, and the disease progression leads to the high prevalence of DR; on the other hand, blood glucose control, diet and exercise management have not yet reached the ideal level, so the incidence of DR is high. To reduce the incidence of DR, we should implement standardized management of DM patients, strengthen the assistance of clinicians and nursing staff to formulate personalized nursing plan, and carry out health education on medication, diet, exercise and psychology. To reduce the incidence of DR, we should implement standardized management of DM patients, strengthen the assistance of clinicians and nursing staff to formulate personalized nursing plan, and carry out health education on medication, diet, exercise and psychology. Disease duration, type of health insurance, medication mode, and the occurrence of DPN are risk factors for the occurrence of DR. Health education regarding retinopathy prevention for diabetic patients, further verification and expansion of health insurance coverage, increased monitoring of glycosylated hemoglobin and diabetic complications, improved fundus monitoring for diabetic patients through digital retinal exams without dilation, and remote screening should be promoted as key measures for DR prevention in the southern part of China.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was approved by the Ethics Committee of Shenzhen Eye Hospital (No. 2017041201), and informed consent was

obtained from all diabetic patients who participated in the screening. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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