·Investigation·

Mayombian ethnic, vegetables low intake, insulin treatment, diabetic nephropathy and severe diabetic retinopathy are determinants of blindness in diabetic Africans

Mvitu Muaka Moise[1], Longo-Mbenza Benjamin[2], Cibanda Yokobo Enoch[3], Longo Phemba Igor[4]

[1]Department of Ophthalmology, Faculty of Medicine, University of Kinshasa, Teaching Hospital, DR Congo
[2]Walter Sisulu University, Faculty of Health Sciences, Private Bag X1, Mthatha 5117, Eastern Cape, South Africa
[3]Department of Anaesthesiology, Nelson Mandela Academic Hospital, Walter Sisulu University, Mthatha 5117, South Africa
[4]School of International Studies, Wenzhou Medical College, Wenzhou 325035, Zhejiang Province, China

Correspondence to: Longo-Mbenza Benjamin. Research Champion Professor, Walter Sisulu University, Faculty of Health Sciences, Private Bag X1, Mthatha 5117, Eastern Cape, South Africa. longombenza@gmail.com
Received: 2012-08-20 Accepted: 2013-08-08

Abstract

• AIM: to determine the frequency and causes of blindness in diabetic Africans.

• METHODS: The study was a cross-sectional survey carried out among known black diabetics consecutively admitted at the Teaching Hospital, University of Kinshasa, between 2005 and 2007. Examination methods included interviewer-administered structured questionnaire, eye examinations (visual acuity, tonometry, funduscopy), and fasting plasma glycaemia test.

• RESULTS: Of the 227 patients examined, 15.9% had blindness. Univariate analyses showed significant association between female, severity of diabetic retinopathy, Mayombian ethnic group, use of insulin treatment, low intake of vegetables, diabetic nephropathy, open angle glaucoma and blindness in all diabetics. After logistic regression, only diabetic nephropathy, use of insulin treatment, macular oedema, Mayombian ethnic group and vegetables low intake were the independent risk factors of blindness in all diabetics. However, after logistic regression in the sub-group with diabetic retinopathy, only open angle glaucoma and proliferative diabetic retinopathy were the independent determinants of blindness.

• CONCLUSION: The majority of the causes of blindness in these diabetic Africans are avoidable. It is recommended that appropriate diabetes care, nutrition education, periodic eye examination and laser photocoagulation facilities should be provided for treating diabetics in sub-Saharan Africa.

• KEYWORDS: diabetes mellitus; blindness; ethnicity; Mayombe; diabetic retinopathy; insulin treatment; Africans
DOI:10.3980/j.issn.2222-3959.2013.05.33

Mvitu Muaka M, Longo-Mbenza B, Cibanda Yokobo E, Longo Phemba I. Mayombian ethnic, vegetables low intake, insulin treatment, diabetic nephropathy and severe diabetic retinopathy are determinants of blindness in diabetic Africans. *Int J Ophthalmol* 2013;6(5):727-732

INTRODUCTION

Diabetes mellitus (DM) is well established as one of the main threats to human health in this 21st century. The World Health Organization stated that the number of diabetics would increase to 552 million by the year 2030[1]. DM is the single most important metabolic disease which can affect nearly every organ system.

People with DM are more likely to develop blindness [2-4]. In African diabetics, the rates of blindness are 9-30% from both community-and hospital-based surveys[5,6].

Age, insulin treatment, diabetic retinopathy (DR), diabetic macular oedema (DMO), cataract, female sex, glaucoma, central retinal vein occlusion, age-related macular degeneration, age ≥60 years, and diabetic nephropathy (DN) are established as risk factors of blindness among African diabetics[5,6].

In Democratic Republic of the Congo (DRC), there is a high prevalence of DM estimated 16% over the age of 15 years[7]. The access to insulin for less than 25% of the time, the higher susceptibility of the Mayombian ethnic group for atherosclerosis, cataract and glaucoma (Longo-Mbenza, unpublished data), the higher prevalence of low intake of vegetables and its impact on pregnancy induced hypertension,

and the lack of good glycemic control are well known [1,8-10]. However, there is no information on their relationship with blindness among diabetics. The objective of this study was to assess whether Mayombian ethnicity, vegetables low intake, insulin treatment, and poor glycemic control in Congolese diabetics determine higher risk of blindness independently from established risk factors.

SUBJECTS AND METHODS

Design, Setting and Study Populati The study was a cross-sectional survey for a non probability sample of known diabetics between December 2005 and December 2007. African and black diabetics screened consecutively at the Division of Ophthalmology, Teaching Hospital of the University of Kinshasa, DRC, between 1970 and 2004, and till alive on 2005, were eligible for participation in this study. Out of 300 diabetic patients with complete medical records, 227 (75.7%) agreed to enrol according to the Helsinki Declaration. The study was approved by the ethical Committee of LOMO Medical Center, Kinshasa Limete, DRC.

Data Collection After receiving informed and verbal consent, these DM patients were interviewed by the Ophthalmologist (Mvitu Muaka Moise). Information about to their sex, age, ethnicity (Mayombian ethnic group *vs* else), types of DM, DM duration, vegetables intake, insulin treatment, arterial hypertension and diabetic complications were collected.

Additionally, fasting blood samples were taken to assess blood glucose levels. All patients underwent a detailed eye examination of both the anterior segment for cataract and glaucoma in one or both eyes and the posterior segment for DR and DMO in one or both eyes. After adequate mydriasis, fundus examination was performed in all patients using indirect ophthalmoscopy through dilated pupils. The intraocular pressure was measured using applanation tonometer.

Fasting plasma glucose (FPG) concentration was estimated by glucose oxidase method (RTU, Biomérieux, Marcy l'Etoile, France) on an analyzer (Hospitalex Spectrophotometer, Italy) at Lomo Medical Center, Kinshasa Limete.

Definitions The interval in years between the DM diagnosis date and the date of the present survey defined DM duration. Longer DM duration was set at level ≥4 years (Median).

The tight glycemic control in these diabetics was impaired by FPG ≥126mg/dL according to the American Diabetics Association (ADA).

The minimum criterion for diagnosis of DR was the presence of at least one definite microaneurysm in any field of fundus. The final diagnosis of DR for each patient was determined by the grading of the most seriously affected eye according to the Early Treatment Diabetic Retinopathy Study criteria: non-proliferative DR (NPDR) absence of signs of DR or presence of microaneurysms, haemorrhages, hard exudates, proliferative DR (PDR) (newly formed blood vessels and/or growth of fibrous tissue into vitreous cavity), and macular edema [11]. NPDR and PDR were classified as mild, moderate or severe according to the stages of severity.

Figure 1 The geographical site of the Mayombe Forest.

Patients belonging to the Mayombian ethnic group (Manianga Isangila, Bamboma, Bayombe, Basundi, Bawowo, Bakongo Boma, Balinzi, Bavilinzi, Basolongo tribes) migrated from the Mayombe Forest (between Angola, Atlantic Ocean, Matadi city, Congo Brazzaville) (Figure 1) to Kinshasa town, the capital of DRC. This region was a part of the Kongo Kingdom discovered by Portuguese sailors around 1 483 and the original homeland of the current majority of African-Americans, Cubanese, Brazilians and Haitians. The Mayombian ethnic group is the first Congolese group to adopt westernization/acculturation (lifestyle changes: tobacco use, high intake of salt, satured fat, and alcohol, urbanization, low vegetables intake) at the beginning of Belgian colonization (1908) and globalization.

Vegetables low intake was considered in case of number <4 portions of vegetables consumption/week[9].

Dense lens detected on slit lamp examination was diagnosed as cataract. Primary open angle glaucoma (POAG) was diagnosed by tonometer readings above 21mmHg. DM macular oedema (MO) was defined according to traditional criteria [12]. DN was diagnosed in the presence of micro-albuminuria and overt proteinuria (macroalbuminuria) with urinary albumin excretion rate=20-199μg/min and ≥200μg/min from sterile random urine samples, respectively[13].

Blindness included cases with visual acuity <6/60 (types of deficiencies or disability)[14].

Statistical Analysis Proportions (%) for categorical variables and means± standard error of the mean (SEM) for continuous variables were obtained. Descriptive analysis, using standard statistical methods was performed. Chi-square tests and Fischer exact tests were used to ascertain the association between blindness and variables. *P* for trend was calculated to assess a dose-effect response relationship between blindness and severity of DR.

Comparisons of means between groups were made using the Student's *t*-test. The Mantel-Haenszel test was used to adjust the relationships between categorical variables for dichotomous confounders, while logistic regression models were used to estimate the simultaneous effect of several determinants on a dichotomous (presence/absence of blindness) outcome in all diabetics and in those with DR. A *P* value$<$0.05 was considered significant. The data were coded and processed on IBM compatible computer, using the Statistical Package for Social Sciences (SPSS) software, version 13 for Windows, SPSS Inc, Chicago, IL, USA).

RESULTS

A total sample (*n*=227) of diabetic Africans of both gender and Congolese nationality was selected. Table 1 presents the general characteristics of all diabetics. Of all, 15.9% (*n*=36) had blindness.

In cases of DR, PDR was rare (*n*=21) in comparison with NPDR (*n*=114) (Figure 2). Out of the 30 cases with open angle glaucoma, 25 diabetics (83.3%) belonged to the Mayombian ethnic group.

Comparisons of characteristics of diabetics with blindness with those of controls are presented on Table 2. The levels of age, DM duration, type 2 DM, hypertension, DR, cataract, FPG and poor glycemic control in the blindness group were similar($P>0.05$) with those in controls. However, compared with controls, the blindness group had higher levels ($P<0.05$) of female, DN, insulin treatment, open angle glaucoma, Mayombian ethnic group, DMO, and low intake of vegetables.

There was a positive dose-effect response relationship (*P* for trend=0.002) between the blindness rates and the severity of DR (Figure 3).

In a multivariate stepwise logistic regression with blindness as dependent variable among all diabetics, only DN, use of insulin treatment, macular oedema, Mayombian ethnic group and low intake of vegetables were found to be significantly and independently associated with blindness (Table 3).

However, only open angle glaucoma and proliferative DR (PDR) were multivariately associated with blindness in the sub-group with DR (Table 4). Infectious causes (Trachoma), and vitamin A deficiency were absent.

Table 1 General characteristics in the study population (*n*=227 diabetics)

Variables of interest	Mean±SEM or *n* (%)
Age (a)	58±0.59
DM duration (a)	7±0.46
M	151 (66.5)
F	76 (33.5)
Mayombian ethnic group	42 (18.5)
Type 1 DM	91 (40.1)
Type 2 DM	136 (58.1)
Age≥60 years	98 (43.2)
Low intake of vegetables	78 (34.4)
Insulin treatment	137 (60.4)
DN	132 (58.1)
DR	135 (59.5)
Macular oedema	90 (39.6)
Glaucoma with open angle	30 (13.2)
Arterial hypertension	133 (58.6)

OR: Odds ratios; DM duration: Diabetes mellitus duration; DR: Diabetic Retinopathy; DN: Diabetic Nephropathy; FPG: Fasting plasma glucose.

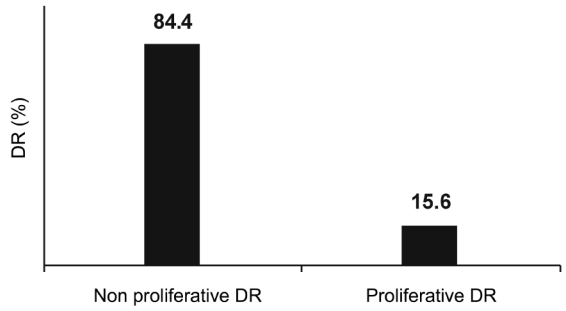

Figure 2 Distribution of patients with diabetic retinopathy (DR) according to the main types of DR.

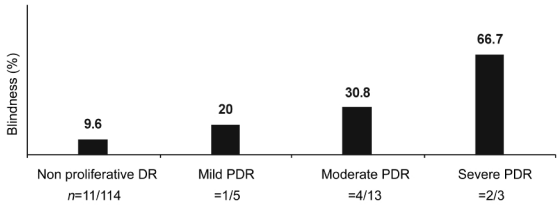

Figure 3 Relationship between blindness and the severity of diabetic retinopathy.

DISCUSSION

This study identified some non modifiable (female, Mayombian ethnic group) and modifiable risk factors of blindness among diabetics in Kinshasa. Urgent programmes of prevention of DM and complications such as blindness are needed to tackle the modifiable and preventable causes of blindness.

Our concern was to find a significant univariate association between female, Mayombian ethnic group, DN, DR severity, vegetables low intake, macular oedema, glaucoma, use of insulin treatment and blindness. Other studies showed similar results to our data [15,16]. Thus, the natural history of blindness

Table 2 Univariate risk factors of blindness among all African diabetics (*n*=227)

Potential risk factors	Blindness *n* (%), OR (95%CI) Mean±SEM	Controls *n* (%) Mean±SEM	*P*
Sex			
Females	17 (47.2),1.5 (1.02-2.3)	59 (30.9)	0.045
Age			
⩾60 years	19 (52.8), 1.3 (0.9-1.8)	79 (41.4)	0.139
DM duration			
⩾4 years	19 (52.8), 1.03 (0.7-1.4)	97 (51.3)	0.509
Type 2 DM	17 (47.2), 0.8 (0.5-1.1)	119 (62.3)	0.067
Hypertension	22 (61.1), 1.1 (0.8-1.4)	111 (58.1)	0.443
DR	22 (61.1), 1.02 (0.5-2.1)	113 (59.2)	0.959
DN	32 (88.9), 1.7 (1.4-2)	100 (52.4)	<0.0001
Insulin treatment	12 (60), 1.7 (1.1-2.5)	47 (36.4)	0.040
Open angle glaucoma	14 (24.1), 2.6 (1.04-6.6)	16 (9.2)	0.044
Mayombian ethnic group	16 (44.4), 3.3 (2-5.4)	26 (13.6)	<0.0001
Macular oedema	20 (55.6), 1.9 (1.04-3.5)	70 (36.6)	0.027
Low intake of vegetables	19 (52.8), 2.5 (1.2-5.2)	17 (47.2)	0.011
Cataract	48 (87.3), 0.4 (0.1-1.5)	162 (94.2)	0.149
FPG (mg/dL)	181.7±17.2	172.3±10.3	0.696
Poor glycemic control	22 (61.1)	111 (58.1)	0.443
DM duration (a)	6±1.3	7.5±0.6	0.336

OR: Odds ratios; DM: Diabetes mellitus; DR: Diabetic retinopathy; DN:Diabetic nephropathy; FPG: Fasting Plasma Glucose.

Table 3 Independent risk factors of blindness among all African diabetics (*n* =227)

Independent variables	B	SE	Wald	OR (95%CI)	*P*
DN	2008	0.587	11.696	7.5 (2.4-23.5)	<0.001
Insulin treatment	0.944	0.469	4.050	2.6 (1.03-6.4)	0.044
Macular oedema	1.237	0.434	8.131	3.5 (1.5-8.1)	0.004
Mayombian ethnic group	1.473	0.442	11.114	4.4 (1.8-10.4)	<0.001
Low intake of vegetables	1.026	0.425	5.816	2.8 (1.2-6.4)	0.016
constant	-8.173	1.699	23.146		<0.0001

OR adjusted for sex, age, DM duration, DM types and hypertension.

Table 4 Independent risk factors of blindness in the sub-group with diabetic retinopathy (*n*=135)

Independent variables	B	SE	Wald	OR (95%CI)	*P*
Open angle glaucoma	2.756	1.191	5.352	15.7 (1.5-162)	0.021
PDR *vs* NPDR	2.582	1.193	4.685	13.2 (1.3-137)	0.030
Constant	-12.451	5.642	4.871		0.027

OR adjusted for sex, age, types of DM, DM duration, insulin treatment, vegetables intake, macular oedema and arterial hypertension.

in these Congolese diabetics is partially explained by our findings obtained from logistic regression models after excluding confounding factors.

The first multivariate analysis used in all diabetic patients suggested that the onset of blindness may result from the interaction of genetic and environmental factors. This is logical as DM is a multifactorial disease. The significant and independent determinants of blindness in these diabetic Africans were DN, use of insulin treatment, macular oedema, Mayombian ethnic group and low intake of vegetables.

The higher risk of blindness in diabetics with DN is explained by proteinuria usually associated with severe forms of DR, visual loss in African-American type 1 diabetics, and blindness in African diabetics[5,6,17,18].

Paradoxically, the use of insulin, abundantly administered in high doses in Africa was associated with the presence of blindness as reported by other studies in diabetic Africans[5,6]. Our recent study has also reported a significant association between use of insulin treatment and DR, another cause of blindness among diabetic Africans [5,6,19]. The delayed diagnosis, the lack of awareness of DM, the severity of DM (high levels of FPG and poor glycemic control), the decline in beta cell function in type 2 diabetics using insulin because of unachieved metabolic control, insulin treatment-induced

immunogenic vascularitis, insulin-related hyperandrogenisation in type 2 diabetic women (female identified univariate risk factor of blindness in this study) and starting insulin treatment in type 2 diabetics with poor glycemic control by oral agents may be incriminated in the pathogenesis of blindness[20-22].

Indeed, tight glycemic control in patients with type 1 DM leads to significant reductions in the risk of early microvascular complications [23]. Therefore, poorer glycemic control prior to insulin use was probably the main reason for the significant association between blindness and insulin treatment observed among these diabetic Africans.

The Mayombian ethnic group is the first indigenuous Central African population to adopt a highly processed food intake with rice, but low intake of vegetables-fruits.

The higher susceptibility of the Mayombian ethnic group for blindness may be explained by their very elevated proportion of open angle glaucoma, cataract and longer westernization (smoking, atherosclerosis, dietary changes, urbanization). Both cigarette smoking (increased monoxide, platelet anomalies), smoking-related eye diseases (cataract, DR, macular degeneration) atherosclerosis-related ophthalmic diseases (retinal artery and vein occlusions) and high saturated intake-associated age-related macular degeneration are associated with visual loss from chronic eye disease in diabetic Africans and diabetics from other continents [5,6,24]. African-Americans sharing the same genetic background with the Mayombian ethnic group despite the higher difference in environment and under treatment of glaucoma present also higher risk of visual loss[25].

The independent role of vegetables low intake in the presence of blindness suggests considering the role of antioxidants and oxidative stress. In these diabetic Africans with epidemiologic and nutrition transitions (low vitamins E, C, folates and potassium, obesity/inflammation), the severity of DR may be amplified by the oxidative stress. Recently released data from the age-related Eye Disease Study indicate that a daily high-dose antioxidant supplement reduces the chance of further vision loss for selected patients with macular degeneration[26].

The absence of significant univariate association between DR and blindness in all diabetic patients may be explained by the classification used (macular oedema separated) and the study-related limitations [27-31]. Our recent study conducted in the community and other African studies showed a significant association between DR (all stages) and blindness[5,6,19].

In conclusion, the diabetes-induced visual disability was related to female, Mayombian ethnic group, open angle glaucoma, MO, DN, proliferative diabetic retinopathy and low intake of vegetables. As such it is important to recommend nutrition education, periodic examination and multidisciplinary management of DM. Dilated stereo photography and timely laser photocoagulation are highly recommended to prevent most of the DR-related blindness in sub-Saharan Africa.

REFERENCES

1 International Diabetes Federation. IDF DIABETES ATLAS Fifth edition, 2011. www.idf.org/diabetesatlas

2 Evans J. Causes of blindness and partial sight in England and Wales 1990-1991. London: HMSO, 1995

3 Kumar N, Goyder E, McKibbin M. The incidence of visual impairment due to diabetic retinopathy in Leeds. *Eye (Lond)* 2006;20(4):455-459

4 Khanderkar R, Mohammed AJ. Visual disabilities among diabetics in Oman. *Saudi Med J* 2005;26(5):836-841

5 Mvitu M, Kimenyembo W, Kaimbo wa Kaimbo D, Driven W, Muls E. Frequency of visual impairment and blindness in Congolese people with diabetes. *Diabetic Medicine* 2006, 23 (Suppl.4) (Posters), 608-753

6 Nwosu SN. Low vision in Nigerians with diabetes mellitus. *Doc Ophthalmol* 2000;101(1):51-57

7 Longo-Mbenza B, Ngoma DV, Nahimana D, Mayuku DM, Fuele SM, Ekwanzala F, Beya C. Screen detection and the WHO stepwise approach to the prevalence and risk factors of arterial hypertension in Kinshasa. *Eur J Cardiovasc Prev Rehabil* 2008;15(5):503-508

8 International Diabetes Federation. Diabetes Atlas, 2nd ed, Brussels, IDF, 2003

9 Longo-Mbenza B, Ngoma DV, Nahimana D, Mayuku DM, Fuele SM, Ekwanzala F, Beya C. Enqu ê te sur les facteurs de risque des maladies non transmissibles à Kinshasa. Capitale de RD Congo. Selon l'approche QTEPS de l'OMS.Minist è re de la Sant è Publique. RD Congo. 2007

10 Longo-Mbenza B, Kadima-Tshimanga B, Buassa-bu-Tsumbu B, M'Buyamba K Jr. Diets rich in vegetables and physical activity are associated with a decreased risk of pregnancy induced hypertension among rural women from Kimpese, DR Congo. *Niger J Med* 2008;17(1):45-49

11 Grading diabetic retinopathy from stereoscopic colour fundus photographs: an extension of the modified Airlie House classification. ETDRS report number 10. Early Treatment of Diabetic Retinopathy Study Research Group. *Ophtalmology* 1991;98(5 Suppl):786-806

12 Willinson CP, Ferris FL 3rd, Klein RE, Lee PP, Agardh CD, Davis M, Dills D, Kampik A, Pararajasegaram R, Verdaguer JT; Global Diabetic Retinopathy Project Group. Proposed international clinical diabetic retinopathy and diabetic macular edema disease severity scales. O*phthalmology* 2003;110(9):1675-82

13 Gross LJL, de Azevedo MJ, Silveiro SP, Canani LH, CaramonI ML, Zelmanovic T. Diabetic nephropathy: diagnosis, prevention and treatment. *Diabetes care* 2005;28(1):164-176

14 Dandona L, Dandona R. Revision of visual impairment definitions in the International Statistical Classification of Diseases. *BMC Med* 2006;4:7

15 Schemann JF, Inocencio F, de Lourdes Monteiro M, Andrade J, Auzemery A, Guelfi Y. Blindness and low vision in Cape Verde Islands: results of a national eye survey. *Ophthalmic Epidemiol* 2006;13 (4): 219-226

16 Longo-Mbenza B, Nkondi Mbadi A Nsungu J, Mbungu Fuele S. Higher

pulse pressure, systolic arterial hypertension, duration of diabetes and family history of diabetes in Central Africans. *Int J Diabetes & Metabolism* 2008;16:17-23

17 Al-Till MI, Al-bdour MD, Ajlouni KM. Prevalence of blindness and visual impairment among Jordanian diabetics. *Eur J Ophthalmol* 2005; 15 (1):62-68

18 Savage S, Estacio RO, Jeffers B, Schrier RW. Urinary albumin excretion as a predictor of diabetic retinopathy, neuropathy and cardiovascular disease in NIDDM. *Diabetes care* 1996;19(11):1243-1248

19 Roy MS, Skurnick J. Six-year incidence of visual loss in African Americans with type 1 diabetes mellitus: the New Jersey 725. *Arch Ophthalmol* 2007;125(8):1061-1067

20 Overview of 6 years' therapy of type Ⅱ diabetes: a progressive disease. U.K. Prospective Diabetes Study Group. *Diabetes* 1995;44(11):1249-1258

21 Kollarits CR, Kiess RD, Das A, Hall AM, Jordan EL Jr, Donovan JE. Diabetic retinopathy and insulin therapy in a rural diabetic population. *Am J Ophthalmol* 1984;97(6):709-714

22 Tron'ko MD, Khalanhot MD, Kravchenko VI, Kul'chyns'ka IaB, Hur'ianov VH, Okhrimenko NV, Neshcheret AP. Gender-related risk of non-fatal stroke, myocardial infarction and blindness in the type 2 diabetic patients depend on the type of treatment. *Lik Sprava* 2006;(1-2):23-27

23 The Diabetic Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993;329(14):977-986

24 Rowe S, MacLean CH, Sheckelle PG. Preventing visual loss from chronic eye disease in primary care: scientific review. *JAMA* 2004;291 (12):1487-1495

25 Javitt JC, McBean AM, Nicholson GA, Babish JD, Warren JL, Krakauer H. Undertreatment of glaucoma among black Americans. *N Engl J Med* 1991;325(20):1418-1422

26 Age-Related Eye Disease Study Research Group. A randomized, placebo-controlled, clinical trial of high-dose supplementation with vitamins C and E, beta carotene, and zinc for age-related macular degeneration and vision loss: AREDS report No.8 *Arch Ophthalmol* 2001; 119(10):1417-1436

27 Klein R, Klein BE, Moss SE, Davis MD, Demets DL. The Wisconsin epidemiologic study of diabetic retinopathy Ⅱ. Prevalence and risk of diabetic retinopathy when age at diagnosis less than thirty years. *Arch Ophtalmol* 1984;102(4):520-526

28 Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. American Diabetes Association: clinical practice recommendations 2002. *Diabetes care* 2002;25Suppl 1:S1-147

29 Klein R, Klein BE, Neider MW, Hubbard LD, Meuer SM, Brothers RJ et al. Diabetic retinopathy as detected using ophthalmoscopy, an non-mydriatic camera and a standard fundus camera. *Ophthalmol* 1985;92: 485-491

30 Moss SE, Klein R, Kessler SD, Richie KA. Comparison between ophthalmoscopy and fundus photography in determining severity of diabetic retinopathy. *Ophthalmology* 1985;92(4):62-67

31 Fong DS, Gottieb J, Ferris FL 3rd, Klein R. Understanding the value of diabetic retinopathy screening. *Arch Ophthalmol* 2001;119(5):758-760