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Retinopathy in adults with hypertension and diabetes mellitus in western Tanzania: A cross-sectional study

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Abstract

Objective—Little is known about the retinal manifestations of arterial hypertension (HTN) and diabetes mellitus (DM) in western Tanzania and how to maximize the utilization of scarce eye health resources. To address this we determined the prevalence of hypertensive and diabetic retinopathy (DR), associated risk factors, and relevant patient knowledge.

Methods—Adults with HTN or DM attending outpatient clinics at Bugando Medical Center (BMC) from June–August 2017 were enrolled. Fundus photos were obtained and data was collected on blood pressure (BP), body mass index (BMI), blood sugar, visual acuity (VA), and responses to questions about the effects of HTN and DM on the eye.

Results—A total of 180 persons were screened. When only individuals with DR were considered, bivariate regression found systolic BP was significantly associated with severity of DR ($p=0.034$). Receiver operating characteristic (ROC) curve analysis using the maximum Youden index revealed the optimum cutoff using duration of DM to predict any DR was 8 years (AUC=0.75, 95% CI 0.65–0.85). Fewer persons with HTN were aware of the effect of high BP on the eye (61.6%) than persons with DM who were aware of the effect of high blood sugar on the eye (74.4%) ($p=0.048$).

Conclusion—Efforts should be made to vigorously treat HTN among adults with DM and refer adults with duration of DM of 8 years or more for a dilated retinal exam. Additional efforts should

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APPENDIX 1 – Tables

APPENDIX 2 – Grading Schemes

APPENDIX 3 – Knowledge and Awareness questionnaire instructions

be made to promote awareness of the sight threatening potential of HTN in resource-limited settings.

Keywords

diabetic retinopathy; hypertensive retinopathy; screening; prevalence; Tanzania; Africa

Introduction

Non-communicable diseases, including HTN and DM, are emerging as leading causes of death and disability on the African continent. In the last 10 years the age standardized mean systolic BP has risen in east, west, central, and southern Africa more than any other region of the world [1]. The burden of HTN is a particular concern in Tanzania, and data on the prevalence of the sequelae of HTN is limited [2–4].

The number of adults (20–79 years) with DM globally is projected to rise from 463 million to 700 million people by the year 2045, with the highest percentage increase to occur in low-income/lower middle-income countries [5,6]. Along with the rise in the prevalence of DM is a rise in vision loss due to the sequela of diabetic eye disease, in particular DR [5].

Although some published data exists on the prevalence of DR and associated risk factors in the Kilimanjaro region of Tanzania [7,8], data is lacking in other regions. Data is available for awareness of Type 2 DM in the adult population of Mwanza city [9], and for awareness of DR among adults with DM attending diabetes clinics in various regions of Tanzania [10]. However, data is lacking on possible associations between patient awareness of DM and prevalence of DR.

Bugando Medical Center (BMC) is a tertiary care hospital in Mwanza serving over 13 million people living in the Lake zone of northwest Tanzania. At the time of this study there were only two Tanzanian ophthalmologists in the region. BMC has partnered with Weill Cornell to address the increasing burden of eye disease in the Lake zone by combining the expertise of ophthalmologists at both centers to carry out a cross-sectional study of people identified with either DM or HTN attending outpatient clinics at BMC. Together we sought to determine the hospital-based prevalence of hypertensive and diabetic retinopathy, associated risk factors, and awareness about the effect of high BP and high blood sugar on the eye. We aimed to describe clinical parameters that can identify people most likely to have retinopathy and to identify gaps in knowledge among people with DM or HTN that can be addressed, all with the goal of improving patient care.

Methods

Between June 14th and August 4th, 2017, BMC conducted a pilot project to screen all adults (over 18 years of age) attending the BMC HTN or DM clinics for retinopathy. The goal of the pilot was to determine the feasibility and possible benefit of a universal screening approach in Tanzanian adults attending HTN and DM clinics. Arterial HTN was defined as a BP of >140/90 on two consecutive clinic visits. DM was defined as fasting blood sugar concentration levels ≥ 126 mg/dL (7.0 mmol/L) or random blood sugar concentration levels

200 mg/dL (11.1 mmol/L) on two consecutive clinic visits. Those consenting had one to three 45-degree fundus photos taken of each eye with a Topcon NW300 non-mydiatic camera (Topcon Medical, Oakland, NJ) without using dilating drops. The images were stored on a password protected laptop with an encrypted hard drive.

Data was collected on BP, BMI, blood sugar, and VA. Blood pressure was taken in the right arm with an Omron (Omron Healthcare Co. Ltd; Kyoto, Japan) M6 portable digital BP device that measured systolic and diastolic BP. The cuff was placed on the bare arm while subjects were seated with their feet on the floor, and BP was measured after subjects were quiet for 3–5 minutes. A single reading was taken. An extra-large cuff with an integrated aneroid was available to measure BP of individuals with an arm larger than the applicable circumference of the digital device. Blood sugar levels were measured from a fingerstick whole blood sample and measured using Contour glucose test strips and a Contour point-of-care blood glucose meter (Bayer Healthcare LLC; Sunnyvale, CA). Distance VA was measured with a multi-letter Snellen eye chart with subjects positioned 6 meters from the chart. Corrected VA was measured in each eye. For the purpose of analysis, the VA of the best eye was used. Visual impairment was defined as VA less than 6/18 in the better eye.

Demographic information and clinical history were obtained by questionnaire. To assess awareness of the effect of high BP and high blood sugar on the eye, an investigator administered a questionnaire with targeted knowledge questions [Appendix 3].

Comprehensive ophthalmologists at BMC trained in the diagnosis of diabetic and hypertensive retinopathy during their four-year ophthalmology training performed the grading of retina photos. All ophthalmologists were masked to subjects' diagnosis and history. Ten percent of the retina photos were randomly selected to be interpreted by a second reader from the Weill Cornell Department of Ophthalmology (New York, NY USA) for quality control. The inter-rater agreement was 100% for all grades of DR and maculopathy, and for Grade 3 and 4 hypertensive retinopathy. Percent agreement including all seven categories measured was 93.9% (263/280). Results for DR and maculopathy were graded based on the minimum data set recommended by the English and Wales National Screening Committee [Appendix 2, 7]. Results for hypertensive retinopathy were graded according to modified Scheie's criteria [Appendix 2, 11].

Statistical analysis

Data was entered into an Excel spread sheet and analyzed, including graphical output, using R version 3.6.3. The eye having the more advanced diabetic or hypertensive retinopathy was used for the analysis. Characteristics of the study population were described using absolute numbers with percentages for categorical variables. Welch's two sample t-test, one-way ANOVA, chi-squared test (with Yates correction), Fisher's exact test, and bivariate regression were used to investigate the relationship between retinopathy outcome and clinical data, demographic factors, and responses to knowledge questions. Bivariate tables were created to summarize independently associated factors with retinopathy outcome. A *p* value of 0.05 was considered statistically significant. Receiver operating curves and two-sample test of proportions were used to assess viability of selected clinical variables as potential discriminants of retinopathy outcomes.

Ethics

Ethical approval was obtained from the Weill Cornell Medical College Institutional Review Board, and from the ethics committees of BMC and the National Institute of Medical Research in Tanzania. Written informed consent was obtained from all study participants.

Results

During the pilot study period, 185 adults were seen in the DM and HTN clinics. Of these, 180 agreed to undergo screening. Common reasons for refusal to participate included concerns about the duration of time needed to complete clinical data collection and respond to the questionnaires. Of the 180 participants enrolled, 6 (3.3%) had images that were ungradable due to media opacity. A total of 174 people had their fundus images graded for hypertensive and diabetic retinopathy. The distribution of outpatient clinics varied, with 83 (47.7%) participants attending HTN clinic, 24 (13.8%) attending DM clinic, and 67 (38.5%) attending with both DM and HTN clinics. Participants were most frequently employed as farmers, and the highest educational level obtained among most participants was primary school (Table 1).

For participants with HTN, the prevalence of any hypertensive retinopathy was 37.3% (95% CI 29.6–45.1%) with Grade I, II, III, and IV hypertensive retinopathy having a prevalence of 12.0% (95% CI 6.8–17.2%), 14.0% (95% CI 8.4–19.6%), 8.7% (95% CI 4.2–13.2%), and 2.7% (95% CI 0.1–5.2%) respectively (Table 2a).

For participants with DM, the overall prevalence of any DR was 42.9 % (95% CI 32.7–53.0%) with background diabetic retinopathy (BDR), pre-proliferative diabetic retinopathy (PPDR), and proliferative diabetic retinopathy (PDR) having a prevalence of 24.2% (95% CI 15.4–33.0%), 13.2% (95% CI 6.2–20.1%), and 5.5% (95% CI 0.8–10.2%) respectively. The overall prevalence of diabetic maculopathy was 26.5 % (95% CI 17.0 – 36.0%) and prevalence of referable maculopathy/clinically significant macular edema (CSME) was 22.9% (95% CI 13.9–31.9%) (Table 2b). Fundus images where haziness due to media opacity interfered with the view of the macula were considered ungradable for maculopathy. All participants with any maculopathy also had findings of DR such that 22 patients (24.2% of all adults with DM) had both DR and maculopathy.

Factors associated with hypertensive retinopathy

The characteristics and questionnaire results of participants with HTN with and without any hypertensive retinopathy are shown in Table 3a [Appendix 1]. Systolic and diastolic BP were strongly associated with any hypertensive retinopathy by bivariate analysis, $p=0.001$ and $p=0.001$ respectively (Table 3a). We explored the relationship between systolic BP and hypertensive retinopathy. Receiver operating characteristic (ROC) curve analysis using the Youden index and the area under the ROC curve (AUC) revealed the optimum cutoff using systolic BP to detect any hypertensive retinopathy was 154 mm Hg (AUC=0.66, 95% CI 0.57–0.75, Table 4). The proportion of participants with systolic BP greater than or equal to 155 mm Hg and any hypertensive retinopathy (48.2%) was significantly greater than the

proportion of participants with systolic BP less than 155 mm Hg and any hypertensive retinopathy (23.1%) ($p=0.0017$, Figure 1).

When participants with HTN were asked, “Can high blood pressure make vision worse?” 85 (61.6 %) responded “yes” and 53 (38.4%) responded “no” or “unsure.” Awareness of the effect of high BP on the eye was not associated with the presence of any hypertensive retinopathy (Table 3a).

Factors associated with diabetic retinopathy and maculopathy

The characteristics and questionnaire results of individuals with DM with and without any DR are shown in Table 3b [Appendix 1]. Duration of DM was significantly associated with both any DR ($p<0.001$) and any maculopathy ($p=0.002$) (Table 3b). We explored the relationship between the duration of DM and any DR. ROC curve analysis using the Youden index revealed the optimum cutoff using duration of DM for detecting any DR was 8 years (AUC=0.75, 95% CI 0.65–0.85, Table 4). The proportion of participants with duration of DM greater than or equal to 8 years and any DR (62.5%) was greater than the proportion of participants with duration of DM less than 8 years and any DR (19.5%) ($p<0.0001$, Figure 2).

We also explored the relationship between systolic blood pressure and DR. When only participants with DM and any DR are considered, in a bivariate regression we found systolic BP was significantly associated with the severity (grade) of DR ($p=0.034$). ROC curve analysis using the Youden index revealed the optimum cutoff using systolic BP for detecting any DR was 149.5 mm Hg (AUC=0.64, 95% CI 0.54–0.74, Table 4). The proportion of participants with systolic BP greater than or equal to 150 mm Hg and any DR (56.2%) was greater than the proportion of participants with systolic BP less than 150 mm Hg and any DR (29.3%) ($p=0.0106$, Figure 3).

When participants with DM were asked, “Can high blood sugar make vision worse?” 64 (74.4 %) responded “yes” and 22 (25.6%) responded “no” or “unsure.” Awareness of the effect of high blood sugar on the eye was not associated with the presence of any DR (Table 3b).

Factors associated with co-morbid hypertension and diabetes mellitus

The characteristics of individuals diagnosed with both HTN and DM are shown in Table 5 [Appendix 1]. Among individuals identified with both HTN and DM, duration of DM was significantly associated with any DR ($p=0.004$) and any maculopathy ($p=0.015$) by bivariate analysis. Among individuals identified with both HTN and DM, diastolic BP ($p=0.004$) and younger age ($p=0.014$) was significantly associated with any hypertensive retinopathy by bivariate analysis (Table 5).

Discussion

This is the first study of the prevalence of diabetic retinopathy, clinically significant macular edema, hypertensive retinopathy, and associated risk factors among persons with HTN and DM in western Tanzania. The results of our investigation highlight the high disease burden

western Tanzania faces from DR, CSME, and hypertensive retinopathy, and provides data to plan screening services and health education for people with DM and/or HTN in the Lake zone.

The prevalence of any DR in our data set (42.9%) is higher than that observed at entry into a DR screening program in the Kilimanjaro region of Tanzania (27.9%) [7]. This may reflect selection bias due to patients attending a tertiary care center clinic having a greater burden of disease. However, our observed prevalence of DR and maculopathy (42.9% and 26.5% respectively) is similar to that found in a household-based study in the Kilimanjaro region of Tanzania (48.6% and 25.7% respectively) [8] suggesting our prevalence results may be generalizable to the population of adults living with DM in Tanzania.

The high prevalence of DR among outpatients attending clinics at BMC will be a heavy burden for the few ophthalmologists in western Tanzania, especially in light of the expected rise in the prevalence of DM in SSA [5,6]. The human resources for eye health, including the number of ophthalmologists, in SSA lags behind that of high resource regions [12]. In addition, the ophthalmic practitioner to population ratio is concentrated in large cities in SSA at the expense of those needing services in rural areas [12].

Our results showing a strong association between duration of DM and any DR suggests duration of DM is a reasonable predictor variable for detecting DR by retinal exam and might allow for determining a cutoff for referral that maximizes benefits for patients living in a resource-poor setting. The AUC statistic derived from our ROC curve analysis using duration of DM to detect any DR indicates 8 years duration of DM provides acceptable discrimination between those with and without DR [13,14]. Our goal is to maximally utilize resources spent performing retinal exams on patients with DM to ensure that those with DR can receive diagnosis and treatment at minimal cost. Thus, referring adults with DM in western Tanzania with duration of DM of at least 8 years to an ophthalmologist may be a reasonable strategy to increase efficiency of DR screening given the severe resource limitations and high cost for patients.

The finding that systolic BP was positively associated with the severity or grade of DR among participants with DM is consistent with the United Kingdom Prospective Diabetes Study (UKPDS), where tight blood pressure control in patients with type 2 DM reduced the rate of progression of DR by 34 % [15]. In another study of 544 high risk type 2 diabetes patients, high BP was a predictor for progression of DR [16]. This suggests vigorous efforts should be made to identify and treat HTN among all adults with DM in western TZ. While the AUC statistic for the prediction of any DR from systolic BP is not as high as the AUC statistic for duration of DM, the relationship between systolic BP and any DR is worthy of further investigation given resource limitations.

Our results demonstrate a strong association between systolic BP and any hypertensive retinopathy. The AUC statistic for the prediction of any hypertensive retinopathy from systolic BP indicates systolic BP has discriminatory ability for detecting any hypertensive retinopathy. However, the AUC value falls under the range generally acceptable for screening purposes [14]. When the systolic BP cutoff determined by ROC curve analysis is

rounded from 154 to 155 mm Hg, the proportion of participants with any hypertensive retinopathy remains significantly greater for participants with systolic BP equal to or greater than 155 mm Hg compared to less than 155 mm Hg. This suggests additional investigation of systolic BP to guide referral of patients with HTN to an ophthalmologist is needed.

Duration of HTN was not associated with hypertensive retinopathy. This may be due to the observation that patterns of retinal vascular changes vary with both current and past BP levels [17] and makes it even more vital that people with HTN in western Tanzania be promptly diagnosed and treated to prevent damage to the retina. This is especially important as Tanzania transitions from a rural to urban society [18,19] given the higher prevalence of HTN in urban versus rural areas [20].

Age was negatively associated with hypertensive retinopathy among individuals with both HTN and DM, with younger age being a risk factor for developing HTN retinopathy. A possible explanation is that early in the course of HTN, the vascular system has not developed compensatory mechanisms, leading to retina damage [21]. Elevated diastolic BP rather than systolic BP was a risk factor associated with hypertensive retinopathy in individuals with comorbid HTN and DM by bivariate analysis. This finding may be explained by the observation that among local factors affecting the retina, retinal diastolic arterial pressure rises before retinal changes appear and that retinal diastolic retinobrachial ratio is more significant than retinal systolic retinobrachial ratio for the development of hypertensive retinopathy [22].

Our questionnaire results for the effect of high BP on the eye suggest awareness of the complications of hypertensive eye disease could be improved among adults with HTN. Nearly 40% of participants with HTN were not aware that HTN could cause eye disease. In low resource settings the perceived severity of medical problems is the most important predictor for healthcare-seeking behavior [23] and poor knowledge is associated with not seeking care for chronic medical conditions [24]. Thus, a lack of understanding of hypertensive eye disease is a potential barrier for individuals with HTN who need treatment, and can be addressed with education programs.

In conclusion, our findings show a readily obtainable historical parameter can identify adults with DM in western Tanzania most likely to have DR and benefit from a retina exam. In particular, referring adults with DM for 8 or more years to an ophthalmologist for a dilated eye exam can allow those with the highest likelihood of DR to be screened. Our findings suggest utilization of scarce ophthalmic resources may also benefit from further study of systolic BP cutoffs for detecting DR in adults with DM. In addition, efforts should be made to maximize the treatment of HTN among all adults with DM given our results showing the severity of DR is associated with systolic BP and the finding that all subjects with the most severe form of DR, PDR, were diagnosed with both HTN and DM. Our results also suggest further study of the relationship between systolic BP and hypertensive retinopathy may allow for determining an optimal systolic BP cutoff for referring adults with HTN for a retina exam. The feasibility of integrating programs to promote awareness of the effect of high BP on the eye into community medical clinics should also be explored.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Proportion with any hypertensive retinopathy by systolic BP cutoff.

Figure 2.
Proportion with any diabetic retinopathy by duration of DM cutoff.

Figure 3.
Proportion with any diabetic retinopathy by systolic BP cutoff.

Table 1

Participant characteristics by condition.

Characteristic <i>Proportion (%) or mean (SD)</i>	HTN* (n=150)	Diabetes* (n=91)	All (n=174)	
				<i>n</i>
Gender				172
Female	84 (56.0%)	57 (62.6%)	102 (59.3%)	
Male	64 (42.7%)	34 (37.4%)	70 (40.7%)	
Age	62.3 (10.7)	59.2 (11.4)	60.6 (11.5)	173
Vision				174
No visual impairment	98 (65.3%)	62 (68.1%)	116 (66.7%)	
Visual impairment	52 (34.7%)	29 (31.9%)	58 (33.3%)	
Duration of disease in years	9.5 (8.8)	9.3 (7.6)	n/a	
Clinic blood glucose in mmol/L	8.0 (3.9)	9.7 (4.1)	8.4 (4.0)	128
Body Mass Index (BMI) in kg/m²	27.41 (5.4)	27.2 (5.4)	27.1 (5.5)	169
Clinic blood pressure in mmHg				171
Systolic	159.8 (27.0)	151.0 (28.8)	155.5 (28.4)	
Diastolic	87.1 (15.7)	83.2 (12.9)	86.4 (15.5)	
Employment				171
Farmer	54 (36.7%)	34 (38.2%)	62 (36.25%)	
Govt, Small business	20 (13.6%)	12 (13.5%)	27 (15.8%)	
Homemaker	22 (15.0%)	10 (11.2%)	24 (14.0%)	
Day labor, Informal	24 (16.3%)	18 (20.2%)	26 (15.2%)	
Student, Unemployed, Other	27 (18.4%)	15 (16.8%)	32 (18.7%)	
Education				167
None, primary	80 (55.5%)	46 (52.9%)	92 (55.1%)	
Secondary, vocational	42 (29.2%)	27 (31.0%)	49 (29.3%)	
University	22 (15.3%)	14 (16.1%)	26 (15.6%)	

* Including participants with both HTN and DM.

Table 2aPrevalence and grade of hypertensive retinopathy among participants with HTN ($n=150$).^{*}

Hypertensive Retinopathy	# of subjects	As percent of subjects with HTN	95% CI
Gr 1	18	12.0	6.8–17.2%
Gr 2	21	14.0	8.4–19.6%
Gr 3	13	8.7	4.2–13.2%
Gr 4	4	2.7	0.1–5.2%
Gr 0 (None)	94	62.7	54.9–70.4%
Total HTN retinopathy	56	37.3%=Prevalence HTN Retinopathy	95% CI 29.6–45.1%

^{*} Participants classified by the eye with the more advanced disease

Table 2bPrevalence and grade of diabetic retinopathy and maculopathy among participants with DM ($n=91$).^{*}

Diabetic Retinopathy	# of subjects	As percent of subjects with DM	95% CI
BDR (Gr 1)	22	24.2%	15.4–33.0%
PPDR (Gr 2)	12	13.2%	6.2–20.1%
PDR (Gr 3)	5	5.5 %	0.8–10.2%
None	52	57.1%	47–67.3%
Total DR	39	42.9% = Prevalence Diabetic Retinopathy	95% CI 32.7–53.0%
Diabetic Maculopathy	# of subjects	As percent of subjects with DM	95% CI
Non-referable	3	3.6%	0–7.6%
Referable (CSME)	19	22.9%	13.9– 31.9%
None	61	73.5%	64–83%
Total Diabetic Maculopathy	22	26.5%=Prevalence Diabetic Maculopathy	95% CI 17.0–36.0%
Ungradable for Maculopathy	8		

^{*} Participants classified by the eye with the more advanced disease.

Table 3aFactors associated with hypertensive retinopathy in outpatients with hypertension ($n=150$).

Characteristic <i>Proportion (%) or mean (SD)</i>	Hypertensive Retinopathy ($n=56$)	No Hypertensive Retinopathy ($n=94$)	<i>p</i> -overall*
Gender			
Female	30 (54.5%)	54 (58.1%)	0.806
Male	25 (45.5%)	39 (41.9%)	
Age	61.0 (11.2)	63.0 (10.5)	0.288
Vision			0.975
No visual impairment	36 (64.3%)	62 (66.0%)	
Visual impairment	20 (35.7%)	32 (34.0%)	
Duration hypertension in years	8.96 (8.1)	9.77 (9.3)	0.595
Clinic blood glucose in mmol/L	7.39 (3.7)	8.26 (4.1)	0.282
Body Mass Index (BMI) in kg/m ²	27.1 (5.5)	27.6 (5.3)	0.557
Clinic Blood pressure in mm Hg			
Systolic	169 (24.8)	154 (26.8)	0.001
Diastolic	94.2 (18.7)	84.2 (12.3)	0.001
Employment			0.544
Farmer	16 (29.6%)	38 (40.9%)	
Govt, small business	8 (14.8%)	12 (12.9%)	
Homemaker	8 (14.8%)	14 (15.1%)	
Day labor, informal	12 (22.2%)	12 (12.9%)	
Student, unemployed, other	10 (18.5%)	17 (18.3%)	
Education			0.349
None or primary	29 (53.7%)	51 (56.7%)	
Secondary or vocational	19 (35.2%)	23 (25.6%)	
University	6 (11.1%)	16 (17.8%)	
Knowledge Question 1 **			0.840
No	6 (11.8%)	8 (9.2%)	
Unsure	15 (29.4%)	24 (27.6%)	
Yes	30 (58.8%)	55 (63.2%)	

* P-values calculated via ANOVA, Kruskal-Wallis or chi-squared (or Fisher's) depending on whether the row variable is continuous normal, continuous non-normal, or categorical.

** Appendix 3

Table 3b

Factors associated with Diabetic Retinopathy ($n=91$) and Maculopathy* ($n=83$) in outpatients with diabetes mellitus.

Characteristic Proportion (%) or mean (SD)	Diabetic Retinopathy n=52	No Diabetic Retinopathy n=39	p- overall**	Maculopathy n=22	No Maculopathy n=61	p- overall**
Gender			1.000			0.712
Female	24 (61.5%)	33 (63.5%)		15 (68.2%)	37 (60.7%)	
Male	15 (38.5%)	19 (36.5%)		7 (31.8)	24 (39.3%)	
Age	58.7 (9.0)	59.5 (13.1)	0.744	60.0 (7.6)	58.8 (12.5)	0.620
Vision			0.974			0.636
No visual impairment	26 (66.7%)	36 (69.2%)		14 (63.6)	44 (72.1)	
Visual impairment	13 (33.3%)	16 (30.8%)		8 (36.4)	17 (27.9)	
Duration of diabetes in years	12.8 (7.8)	6.7 (6.4)	<0.001	14.0 (8.0)	7.5 (6.7)	0.002
Clinic blood glucose in mmol/L	9.88 (4.3)	9.5 (4.0)	0.686	10.5 (5.1)	9.4 (3.9)	0.391
Body Mass Index (BMI) in kg/m²	26.8 (4.8)	27.5 (5.8)	0.561	26.6 (5.6)	27.0 (5.1)	0.759
Clinic Blood pressure, mm Hg						
Systolic	157 (26.5)	147 (30)	0.095	159 (21.8)	149 (31.4)	0.118
Diastolic	83.8 (11.9)	82.8 (13.8)	0.727	85.0(11.8)	83.0 (13.9)	0.515
Employment			0.508			0.697
Farmer	13 (35.1%)	21 (40.4%)		7 (33.3%)	23 (38.3%)	
Govt, small business	6 (16.2%)	6 (11.5%)		3 (14.3%)	8 (13.3%)	
Homemaker	6 (16.2%)	4 (7.69%)		3 (14.3%)	5 (8.3%)	
Day labor, informal	8 (21.6%)	10 (19.2%)		6 (28.6%)	12 (20.0%)	
Student, Unemployed, Other	4 (10.8%)	11 (21.1%)		2 (9.5%)	12 (20.0%)	
Education			0.187			0.174
None or primary	22 (57.9%)	24 (49.0%)		12 (54.5%)	28 (48.3%)	
Secondary or vocational	13 (34.2%)	14 (28.6%)		9 (40.9%)	17 (29.3%)	
University	3 (7.9%)	11 (22.4%)		1 (4.5%)	13 (22.4%)	
Knowledge question 2***			0.140			0.049
No	4 (11.1%)	3 (8.3%)		4 (18.2%)	3 (5.4%)	
Unsure	3 (8.3%)	12 (24.0%)		1 (4.6%)	13 (23.2%)	
Yes	29 (80.6%)	35 (70.0%)		17 (77.3%)	40 (71.4%)	

* Those ungradable for maculopathy were removed.

*** P-values calculated via ANOVA, Kruskal-Wallis or chi-squared (or Fisher's) depending on whether the row variable is continuous normal, continuous non-normal, or categorical.

Appendix 3

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Table 4

Optimal screening cutoffs based on the maximal Youden index and associated measures of performance.

Condition (screening parameter)	Value	95% confidence interval
Diabetes (Duration Diabetes)		
Optimal cut point (years)	8.0	
Area under ROC curve (AUC)	0.75	0.65–0.85
Sensitivity (%)	78.9	82.7–90.4
Specificity (%)	64.7	50.1–77.6
Positive predictive value (%)	62.5	47.7–80.8
Negative predictive value (%)	80.5	64.9–88.6
Diagnostic likelihood ratio (+)	2.24	1.49–3.36
Diagnostic likelihood ratio (–)	0.33	0.17–0.62
Diabetes (Systolic Blood Pressure)		
Optimal cut point (mm Hg)	149.5	
Area under ROC curve (AUC)	0.64	0.54–0.74
Sensitivity (%)	69.2	52.4–83.0
Specificity (%)	58.0	43.2–71.8
Positive predictive value (%)	56.2	41.2–70.5
Negative predictive value (%)	70.7	54.5–83.9
Diagnostic likelihood ratio (+)	1.65	1.12–2.43
Diagnostic likelihood ratio (–)	0.53	0.31–0.90
Hypertension (Systolic Blood Pressure)		
Optimal cut point (mm Hg)	154	
Area under ROC curve (AUC)	0.66	0.57–0.75
Sensitivity (%)	74.5	61–85.3
Specificity (%)	53.8	43–64.2
Positive predictive value (%)	48.8	38.3–65.4
Negative predictive value (%)	78.1	78.1–65.6
Diagnostic likelihood ratio (+)	1.61	1.23–2.11
Diagnostic likelihood ratio (–)	0.47	0.29–0.77

Table 5

Factors associated with Hypertensive Retinopathy, Diabetic Retinopathy and Maculopathy in outpatients with both hypertension and diabetes mellitus ($n=67$).

Characteristic	HTN Retinopathy n=21	No HTN Retinopathy n=46	<i>p</i> - overall*	Diabetic Retinopathy n=31	No Diabetic Retinopathy n=36	<i>p</i> - overall*	Maculopathy n=18	No Maculopathy n=44	<i>p</i> - overall*
Gender			1.000			1.000			0.552
Female	12 (57.1%)	27 (58.7%)		18 (58.1%)	21 (58.3%)		12 (66.7%)	24 (54.5%)	
Male	9 (42.9%)	19 (41.3%)		13 (41.9%)	15 (41.7%)		6 (33.3%)	20 (45.5%)	
Age	58.5 (6.9)	64.0 (10.4)	0.014	61.0 (6.1)	63.3 (12.0)	0.323	61.2 (6.6)	62.5 (10.5)	0.560
Vision			1.000			0.942			0.812
No impairment	14 (66.7%)	30 (65.2%)		21 (67.7%)	23 (63.9%)		11 (61.1%)	30 (68.2%)	
Impairment	7 (33.3%)	16 (34.8%)		10 (32.3%)	13 (36.1%)		7 (38.9%)	14 (31.8%)	
Duration HTN	8.16 (6.1)	10.8 (9.7)	0.197	12.2 (9.7)	8.44 (7.8)	0.115	10.1 (8.0)	9.78 (8.8)	0.887
Duration DM	11.0 (8.3)	9.36 (8.1)	0.460	13.0 (8.3)	7.20 (7.1)	0.004	13.9 (8.2)	8.10 (7.2)	0.015
Clinic blood glucose	8.97 (4.1)	9.62 (4.3)	0.563	9.58 (4.4)	9.29 (4.4)	0.779	10.4 (5.4)	9.19 (3.8)	0.404
BMI	27.8 (4.8)	27.9 (5.3)	0.922	27.4 (4.5)	28.3 (5.6)	0.448	27.6 (5.5)	27.5 (4.8)	0.972
Blood pressure									
Systolic	166 (17.6)	157 (29.6)	0.122	163 (24.8)	156 (28.3)	0.323	163 (21.7)	159 (28.9)	0.587
Diastolic	92.2 (11.4)	82.5 (12.9)	0.004	84.9 (11.9)	85.9 (14.3)	0.762	86.4 (12.3)	85.6 (13.9)	0.816

* P-values calculated via ANOVA, Kruskal-Wallis or chi-squared (or Fisher's) depending on whether the row variable is continuous normal, continuous non-normal, or categorical.