AOSIS

Implementation and evaluation of a team approach to managing diabetes mellitus and diabetic retinopathy in the South African district health system

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Background: Diabetic retinopathy (DR) screening programmes have been developed and implemented in different countries based on availability of resources. Most protocols developed for DR have been solely dedicated to DR screening without involving systemic screening.

Aim: To implement and evaluate a DR screening model utilising a team of healthcare practitioners (HCPs) to manage diabetes mellitus (DM) to reduce DR progression.

Setting: Primary healthcare clinics and Voortrekker hospital in Waterberg district of Limpopo province.

Methods: A cross-sectional study was conducted, in which a total of 107 patients with DM from seven clinics consented to participation. A proposed DR screening model was implemented where patients with DM were screened for systemic complications at clinics and referred to Voortrekker district hospital for retinal photography. Questionnaire responses evaluated the success of the screening process and operational challenges.

Results: From the study population, 32 (29.1%) were male and 75 (70.1%) were female. The mean age of patients was 63.7 years with a mean weight of 80.69 kg. The mean duration of DM was 9.26 years and the mean haemoglobin A1c (HbA1c) level was 9.7%. From the 47 patients who had visual acuity less than 6/9, 74.5% had refractive error. About 10% (9.4%) had DR or diabetic macular oedema (DME) and 38.3% had other lesions. Referral to an ophthalmologist was necessary in 36.5% of cases.

Conclusion: The implementation of a team approach to co-manage DM and DR utilising the developed protocol improved the quality of care for patients with DM in the district health system.

Keywords: diabetes mellitus; diabetic retinopathy; screening programme; health care practitioners; district health system; primary health care.

Introduction

Diabetes mellitus (DM) is a global pandemic[1] affecting patients in their most productive years. It is a lifestyle disease, unless genetically inherited, associated with modifiable risk factors such as hypertension and obesity, and non-modifiable risk factors such as ageing, ethnicity and family history.[2] The microvascular and macrovascular complications of DM impact on patients' quality of life, contributing to high morbidity and mortality rates.

Microvascular and macrovascular complications in DM may develop simultaneously.[3] Complications include cerebrovascular disease, cardiovascular disease (CVD), peripheral vascular disease, nephropathy, neuropathy and diabetic retinopathy (DR). The microvascular complications of DM are governed by the polyol pathway, which is activated by persistent hyperglycaemia.[4] Hyperglycaemia is measured using an haemoglobin A1c (HbA1c) test, which assesses the average glucose level of the previous 2–3 month period.[5] Poor HbA1c levels have been associated with the development and progression of DM complications.[6] Macrovascular complications of DM have been found to be associated with insulin resistance more than hyperglycaemia.[7] High insulin resistance has been found to increase CVD risk by 2.5-fold.[8]

Insulin resistance and hyperglycaemia have also been driving factors in the development of non-alcoholic fatty liver disease (NAFLD). The spectrum of pathological conditions of NAFLD ranges

from simple steatosis to non-alcoholic steatohepatitis to cirrhosis and hepatocellular carcinoma.[9] Type 2 DM and obesity have been identified as risk factors for the development of NAFLD.[10] It has been established that CVD risk increases by 1.87-fold in patients with NAFLD in the presence of Type 2 DM.[11] Non-alcoholic fatty liver disease also increases microvascular complications of DM such as chronic kidney disease and DR.[12] The gold standard for diagnosing NAFLD is a liver biopsy to identify liver steatosis and carcinoma. However, in the absence of liver steatosis, the recommended treatment is a weight loss and exercise programme to enhance insulin sensitivity to promote the reduction of liver steatosis.[13]

Diabetic retinopathy, cataract and glaucoma are common ocular manifestations of DM.[14] Uncorrected refractive errors (myopia, hyperopia and astigmatism) are generally a major cause of low vision and blindness. Low vision is defined by two categories, namely moderate visual impairment (VI), which is presented by visual acuity (VA) less than 6/18 but equal to or better than 6/60 and severe VI, which is presented by VA less than 6/60 but equal to or better than 3/60.[15] Factors responsible for uncorrected refractive errors include the lack of awareness and recognition of the problem, non-availability of refractive services or inability to afford refractive services and cultural disincentives to compliance.[15] Refractive changes in patients with DM can be acute or chronic or progressive as associated with an increase in myopia.[16] An increase in crystalline lens thickness is known to increase the prevalence of late-onset myopia in patients with DM.[17,18]

Diabetic retinopathy has the potential to affect all patients with DM and severe DR has been associated with the presence of neuropathy and nephropathy.[19] Patients with DR may not experience symptoms of vision loss until it becomes too late to treat, leading to irreversible blindness. Some patients with DR may only notice vision deterioration if they develop cataracts. Cataract is the most common ocular complication of DM and is considered a major cause of VI in patients with DM in developed and developing countries.[20] Patients with DM are 4–5 times more likely to develop cataracts with an early onset.[21] Despite advancement techniques for cataract surgery (phacoemulsification), poor VA following cataract surgery has been associated with posterior capsular opacification, post-operative cystoid macular oedema, diabetic macular oedema (DME) and worsening of DR in patients with DM.[20]

Patients with DM have an increased risk of developing primary open angle glaucoma (POAG).[22] A glaucoma suspect is defined as an individual with clinical findings and/or a constellation of risk factors that indicate an increased likelihood of developing POAG.[23] These clinical findings and risk factors range from having high intraocular pressure (IOP), optic nerve head or retinal nerve fibre layer (RNFL) appearances suggestive of glaucomatous damage, unexplained visual field defects and abnormal angles to a positive family history of glaucoma.[24,25] An IOP greater than 21 mmHg was traditionally set as a criterion for the suspicion of glaucoma.[26] Other studies have also used this criterion.[14,25] It was observed from the study of Baisakhiya et al.[27] that patients with poor glycaemic control had higher IOPs and Hymowitz et al. revealed that it was unlikely for patients with elevated HbA1c levels to have low IOPs.[28]

Ideally, in the holistic co-management of patients with DM, HCPs should be educating patients on systemic and ocular complications, which may arise when the DM is not adequately controlled. With the rising incidence of DM, there is a growing focus by HCPs towards assisting patients with DM management because self-management poses a challenge.[29] Values for DM detection have been documented, yet these values may appear meaningless to the illiterate or uneducated and may be underestimated by them.

As a result of the asymptomatic nature of DR, early detection of DR is essential to prevent further progression and potential vision loss. Health education is meant to be promoted at each level of care in the district health systems (DHS) involving primary healthcare (PHC) nurses, medical officers (MOs), ophthalmic nurses and optometrists. However, concerns have been expressed regarding the lack of policies dedicated solely to eye health promotion in South Africa (SA) where policies have been dedicated to curative rather than preventative measures.[30] Patients with DM require comprehensive management by a team of HCPs to manage both systemic and ocular complications to prevent and reduce the progression of blindness because of diabetic eye disease. This highlights the need for a DR screening model in the DHS to co-manage patients with DM and DR.

Methodology

An observational study using convenience sampling was employed whereby 201 patients with DM from the seven catchment area clinics for Voortrekker district hospital were recruited for participation from 01 October 2018 to 31 March 2019. From 201 recruited patients, 107 consented to participation (Table 1). The study made use of the input, processes and output approach (Appendix 1). The duration of the retinal screening process was from 08 April 2019 to 30 May 2019.

Visual acuity was assessed using a Snellen VA chart. A Tumbling E chart was used to assess VA of illiterate patients. A handheld autorefractor (measuring distance of 1 m ± 5 cm), known as the Eurofractor, was used to determine refractive error of patients with VA less than 6/9. The refractive error was subjectively refined using trial frame refraction. The i-Care tonometer was used to assess IOP and the Tomey non-mydriatic fundus camera (model TFC-1000 with resolution of 4096 × 3072 mega pixels and a field of view of 45 up to 80°) was used to capture retinal images.

After consenting to participation, patients were given appointment cards for their retinal screening dates by the

PHC nurses and referred to the MO for blood testing and medical assessment. Transport arrangements were made for patients to be transported from the clinics to Voortrekker district hospital for the ocular screening assessment. Patients profile details (gender and age), case history (duration of DM, presence of hypertension, medication compliancy, presence of a meal plan, presence of neuropathy and family history of DM) and vital signs (weight, glycaemia, blood pressure and HbA1c levels) were documented on the record card by the PHC nurses prior to patients' arrival for retinal screening. Blood tests were also performed and results were analysed by the MO who recorded findings of cardiovascular, kidney and liver dysfunction on the record card prior to the retinal screening process. On patients' arrival, the optometrist (principal investigator) conducted the ocular screening tests as per protocol (VA assessment, pinhole test, refractive error, IOP assessment, retinal photography, DR screening and grading). Retinal photography images were graded using a combination of the Scottish Grading Classification System and United Kingdom National Grading Classification, whereas other ocular lesions were documented on the record card under other lesions (OL). Photographic images of both eyes of each patient were saved to a flash drive which was hand-delivered to the ophthalmologist at Mankweng hospital for DR grade verification and the verification of OL (such as cataract and glaucoma suspects). All retinal photographs were assessed and patients requiring referrals to the ophthalmologists were given appointment dates for referral to either Mankweng or FH Odendaal hospitals based on the equipment and treatment available at those institutions.

On completion of the screening process, satisfaction survey forms were distributed to all the HCPs involved in the screening programme to evaluate the screening process. These included 107 patients, 14 PHC nurses, one MO and one ophthalmologist. A modification of the approach was performed after conducting a strength, weakness, opportunity and threat (SWOT) analysis of the screening process. Based on the responses, recommendations were made to support the DR screening model.

Data were analysed using standard descriptive statistics (proportions and frequencies) to describe all categorical variables and mean with standard deviations for continuous variables. The Fisher's test was used to test for associations between categorical variables. Spearman's rank correlation coefficient tests were used to measure correlations between continuous variables and the Mann–Whitney U tests were used to compare continuous variables between two groups because of non-normality and small samples.

Ethical consideration

Approval to conduct the study was received from the Biomedical Research Ethics Committee, University of KwaZulu-Natal (BREC reference no. 272/18). Ethical clearance was granted before commencement of the study.

Permission to conduct the research study was obtained from the Department of Health Limpopo Province and the respective Heads of Institutions at clinics and hospitals. Information relating to the study was provided and informed consent was obtained from all participants.

Results
Results of implementation phase
Discussion

Poor glycaemic control has been identified as an important predictor to the development and progression of DR.[31] In this study, a correlation between the hyperglycaemic level and HbA1c level was found (Spearman's rho = 0.58). Although 98.1% of patients were supposedly compliant with treatment for DM as seen in Figure 1, 77.3% reflected HbA1c levels of > 7% showing poor control of DM. Only 8.4% patients complied with proper meal planning. There was an association found between HbA1c levels greater than 7% and hyperglycaemia levels greater than 10 mmol/L (Fisher's exact = 0.001; Table 2). Cardiac markers to detect cardiovascular disorders and liver function test assessments were done on 64 out of 107 (59.8%) patients. Of the 64 patients, 57 (89.1%) suffered liver disorders, and this was unlikely due to NAFLD because of the low prevalence of obesity (5.6%). It was, however, not established whether the high prevalence of liver disorders was because of alcohol abuse and/or nutritional deficiencies. Creatinine levels to assess kidney dysfunction were done on 55 out of 107 (51.4%) patients.

Refraction was conducted in patients with VAs less than 6/9 (32.7%) and myopia was the most common refractive error found. The study conducted by Gwinup and Villarreal[18] established that patients with DM developed more myopia after the injection of glucose, which was because of the accumulation of by-products of glucose metabolism within the crystalline lens causing lens swelling and inducing myopia. An acute decrease in plasma glucose concentration has, therefore, been associated with hyperopia.[18] In this study, of the 14 patients who had severe
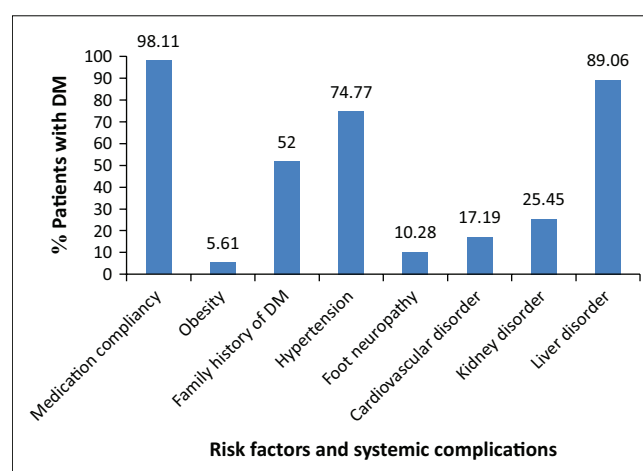
DM, diabetes mellitus.

FIGURE 1: Risk factors and complications associated with diabetes mellitus.

TABLE 1: Database of 201 patients with diabetes mellitus and number of participants (107) who consented to participate in the screening programme.

Name of clinic	Total number of patients with DM		Total number of participants	
	n	*%*	*n*	*%*
Bokwalakwala clinic	44	21.89	22	20.56
Ga-Madiba	26	12.94	26	24.30
Gateway	35	17.41	21	19.63
Mahwelereng 1	10	4.98	10	9.35
Mahwelereng 2	36	17.91	11	10.28
Manyoga (new clinic; opened March 2019)	13	6.47	8	7.48
Sekgakgapeng	37	18.41	9	8.41
Total	**201**	**100.00**	**107**	**53.23**

DM, diabetes mellitus.

TABLE 2: HbA1c levels greater than 7% and hemo-glucose test levels greater than 10 mmol/L.

HbA1c	HGT				Total	
	> 10		≤ 10			
	n	*%*	*n*	*%*	*n*	*%*
> 7	31	54.39	26	45.61	57	100.00
≤ 7	2	11.11	16	88.89	18	100.00
Total	**33**	**44.00**	**42**	**56.00**	**75**	**100.00**

Fischer's exact test: $p = 0.001$.
HGT, hemo-glucose test.

TABLE 3: Visual acuity, intraocular pressure, refractive error of patients with diabetes mellitus.

Categories	Right eyes		Left eyes	
	n	*%*	*n*	*%*
Visual acuity				
≥ 6/9	62	57.94	60	56.07
6/12–6/18	17	15.89	20	18.69
6/18–6/60	14	13.08	16	14.95
≤ 6/60	14	13.08	11	10.28
Total	107	100.00	107	100.00
Intraocular pressure				
< 21	105	98.13		4.39
> 21	2	1.87	6	5.61
Total	107	100.00	107	100.00
Refractive error				
Myopia	22	62.86	22	62.86
Hyperopia	9	25.71	9	25.71
Astigmatism	13	37.14	12	34.29
Total	35	100.00	35	100.00
No pinhole improvement	10	9.35	7	6.54

TABLE 4: Hypertension and glaucoma suspect per eye.

Presence of HPT	Glaucoma suspect (EYE = OD)				Total	
	No		Yes			
	n	*%*	*n*	*%*	*n*	*%*
Right eyes (EYE = OD)						
No	23	85.19	4	14.81	27	100.00
Yes	68	85.00	12	15.00	80	100.00
Total	91	85.05	16	14.95	107	100.00
Left eyes (EYE = OS)						
No	24	88.89	3	11.11	27	100.00
Yes	68	85.00	12	15.00	80	100.00
Total	**92**	**85.98**	**15**	**14.02**	**107**	**100.00**

Fischer's exact test: $p = 1.000$ for right eye and $p = 0.756$ for left eye.
HPT, hypertension; EYE = OD, oculus dexter (right eye); EYE = OS, oculus sinister (left eye).

There was no association found between hypertension and glaucoma suspects (Fishers exact test; $p = 1.000$ for right eye and $p = 0.756$ for the left eye) as seen in Table 4. The ocular complications co-existing with the glaucoma suspects included cataracts in three (18.8%) patients, DR in two (12.5%) patients and hypertensive retinopathy in one (6.2%) patient.

Cataract was the most common ocular complication found (Table 5) causing blindness in six out of 11 (54.6%) patients in the right eye and five out of 14 (35.7%) in the left eye. Longer duration of DM has been associated with an increased frequency of cortical cataract and increased frequency of cataract surgery.[33] In this study, there was no association found between the duration of DM and presence of cataract (Mann–Whitney U test; $p = 0.65$ in the right eye and $p = 0.32$ in the left eye). The median (IQR) duration of DM in the group with cataracts was 10 (7–12) and 10 (6–10) in the group without cataracts for the right eyes. For the left eyes, the medians (IQR) of 10 (6–10) and 8 (5–10) were found in the groups with and without cataracts, respectively.

Two of the five patients with DR (40%) and three of the four (75%) with DME in the right eye showed poor control of their glycaemic level (HbA1c > 7%). The HbA1c level of the other three patients with DR and one with DME was not tested. In the left eye, three of the five patients with DR (60%) and two of the five with DME (40%) showed poor glycaemic control. The HbA1c level of the two patients with DR and two with DME was not tested and only one patient with DME had an HbA1c level less than 7%.

visual impairment (SVI), 71.4% had myopia in the right eye and 75% in the left eye.

A total of 16 (14.9%) patients were identified as glaucoma suspects. Of the 16 patients, eight (50%) had IOP > 21 mmHg (Table 3), whereas the other eight displayed optic discs or RNFL appearances suspicious of glaucomatous damage. In these patients, the ISNT rule (measurements of disc rim thickness of inferior ≥ superior ≥ nasal ≥ temporal)[32] was not obeyed. No correlation between IOP and HbA1C was found (Spearman's rho = 0.27 for right eye and 0.18 for left eye). However, of the eight patients who had IOPs greater than 21 mmHg, six (75%) had HbA1c levels of more than 7% and this finding concurred with the studies of Baisakhiya et al.[27] and Hymowitz et al.[28] showing that patients with poor glycaemic control have higher IOPs. The HbA1c level in the other two patients was not assessed.

TABLE 5: Diabetic retinopathy and other ocular lesions in 107 patients with diabetes mellitus.

Categories	Right eyes		Left eyes	
	n	%	n	%
DR and DME				
Preproliferative DR	5	4.67	5	4.67
Proliferative DR	0	-	0	-
DME:	-	-	-	-
Non-clinical significant DME	3	2.80	4	3.74
Clinically significant DME	1	0.93	1	0.93
Total	9	8.41	10	9.35
Other ocular conditions				
Cataract	16	14.95	17	15.89
Glaucoma suspect	16	14.95	15	14.02
Hypertensive retinopathy	4	3.74	5	4.67
Myopic retinopathy	1	0.93	1	0.93
Peripapillary atrophy and macular star	1	0.93	-	-
Pterygium	1	0.93	1	0.93
Retinal scar	1	0.93	-	-
Choroidal atrophy with myopic crescent	-	-	1	0.93
Previous retinitis	-	-	1	0.93
Traumatic cataract	-	-	1	0.93
Retinal detachment	-	-	1	0.93
Total	40	37.38	43	40.17

DR, diabetic retinopathy; DME, diabetic macular oedema.

Patients with pre-existing DME were found to have the worst prognosis for visual rehabilitation after cataract surgery.[34,35] Treatment guidelines have been recommended for pre-existing DR and DME, which indicate annual screening for no DR and for mild non-proliferative DR (NPDR).[36] A study conducted at a district hospital in SA revealed that 42.9% of patients with DM had refractive disorders and also confirmed that suspected glaucoma, cataracts and DR were prevalent eye conditions amongst patients with DM.[37]

From the patients' satisfaction survey in Table 6, the two patients who experienced transport problems utilised their own transport to the hospital for retinal screening. For one patient, this was by choice but the other missed the transport from the clinic because of late arrival and incurred a R50.00 travel cost. One patient waited for a long time at the clinic to be transported to the hospital for eye screening as she presented before 06:00 at the clinic and transport was scheduled for 09:00. More patients requested additional education on wound healing, foot care, dental care and blood pressure control than on diet and hyperglycaemia control. Some patients reported removing their own teeth and assumed that the use of false teeth does not require dental care. Additional information requested was on weight loss, urinary incontinence, body rash, management of headaches, hearing loss and advice on social grants because of unemployment. They also complained about suffering from other ailments such as cough, shortness of breath, swollen legs and getting chest irritation after taking ibuprofen. Other concerns raised were the unavailability of insulin injections, hypertension and DM treatment on certain days at clinics. In addition, they complained that on some days, blood pressure machines and glucometers were not working and occasionally

TABLE 6: Results of patients' satisfaction survey completed by 107 participants.

Categories	Yes		No	
	n	%	n	%
Screening process				
Satisfied with screening process	107	100.00		
Transport challenges	2	1.87	105	98.13
Long duration of screening process			107	100.00
Long waiting period at clinic	1	0.93	106	99.07
Incurred travel cost to clinic	1	0.93	106	99.07
Experienced poor staff attitudes			107	100.00
Poor communication by staff			107	100.00
Education given by staff at the clinic helpful in controlling DM	83	77.57	24	22.43
Additional education required for				
Diet	56	53.33	49	46.67
Foot care	74	69.16	33	30.84
Blood pressure control	61	57.01	46	42.99
Hyperglycaemia control	49	45.79	58	54.21
Wound healing	79	73.83	28	26.17
Dental care	67	63.21	39	36.79

DM, diabetes mellitus.

there were no glucose test strips. Another challenge was to get pills on time because of stock unavailability and misunderstanding of the dosages of alternative treatments prescribed when regular prescribed treatment was out of stock. At times no eye treatment was available at the clinics and hospital. There was not enough seating place at the clinics. A few reported that it was a challenge when it rained as they sit outside and when there is no shade this brings on headaches.

From the HCPs satisfaction survey in Table 7, the PHC nurses reported that the screening programme enhanced their knowledge and the knowledge of patients with DM. It was, however, a challenge to recall patients as their cell numbers were either on voicemail or no longer operational. At times, different test tubes were not available to collect blood samples. Patients were also not always compliant with treatment because of the unavailability of insulin injections at times. Occasionally, pills for high blood and DM were also not available. They suggested that the DR screening protocol be implemented for better service delivery as patients appreciated the opportunity of seeing the 'pictures of their eyes' for the first time. A staff member who was also a participant reported that the research was very helpful because of her own diabetic history. It was the first time that her blood was taken and tested. She was always worried about other undiagnosed conditions and never knew what her creatinine level was but now through this research, she had this opportunity to find out. Her sister passed on because of late diagnosis of liver disease; she was on dialysis after suffering from kidney failure. Another PHC nurse also reported that relatives of a patient were very pleased about the DR screening protocol as the patients' eye was operated within 2 months after being screened. The patient could now see better and manage to do things independently. The MO appreciated the effort demonstrated by the principal investigator to implement a team approach for early detection of DR.

TABLE 7: Results of primary healthcare nurse and medical officers satisfaction survey completed by 15 primary healthcare nurses and one medical officers.

Screening process	Yes		No	
	n	**%**	**n**	**%**
Satisfied with protocol	15	100.00	0	-
Sufficient space to screen patients	14	93.33	1	6.66
Involvement in other screening programmes	0	-	15	100.00
Necessary equipment available to screen patients with DM	12	80.00	3	20.00
Able to cascade information and knowledge of the screening programme to colleagues	15	100.00	0	-

DM, diabetes mellitus.

The ophthalmologist reported seeing more than 100 DR cases per month and doing 60–70 laser photocoagulation treatments per month. The ophthalmologist was satisfied with the photographic images of the fundi and revealed that 80% of images were appropriately graded by the optometrist. She reported having sufficient space to examine and manage DR cases and also having treatment available for DR and DME. However, she reported not having sufficient staff to assist with DR cases and her request was for more ophthalmologists to be appointed to assist with DR case management.

Strength, weakness, opportunity and threat analysis

Strength: Staff revealed that patients were satisfied with the screening programme and wanted this programme to continue. There was an influx of patients making enquiries at the clinic about the booking system for retinal photography after the screening programme was completed. Patients reported never having been screened with a camera and appreciated the time taken on the additional education given on diet, foot care and dental care. The project's success was supported by the PHC nurses, MO on outreach, ophthalmologist and laboratory assistants. The PHC nurses saw the relevance of having a formal database for patients with DM. The MO in collaboration with the PHC nurses conducted the blood testing, which was sent to the laboratory at Voortrekker hospital for analysis and the progress could be easily tracked as the laboratory was on the premises of Voortrekker hospital.

Weakness: The commitment to provide a diabetic patient database from the data capturers working at the clinics was poor. In the absence of a diabetic patient database, the PHC nurses only recruited patients presenting at the clinic over a period of 6 months (October 2018 to Mach 2019). Patients' contact numbers on their files were non-existent and unreliable making it difficult to recruit more patients. A few blood pressure readings were not taken at the clinics because of non-operational batteries. Blood samples were not taken of every patient because of the unavailability of test tubes on some screening dates. Some patients did not comply with going back to the clinics for retesting of blood. Certain markers that could not be analysed because of the restrictions in the laboratory facility had to be sent to the laboratory in Polokwane for analysis and a few blood samples were misplaced. Body mass index (BMI) could not be calculated by the PHC nurses because only weight was measured and not height.

Opportunity: Retinal photography created an opportunity to motivate patients for better glycaemic control. The goals of the screening programme are in line with those of the World Health Organisation (WHO), International Diabetes Federation (IDF) and National and Provincial Departments of Health. The programmes innovation could be replicated in other provinces and other parts of Africa. The programme offers an opportunity for training and employment for optometrists and ophthalmic nurses.

Threat: As a result of the lack of staff in the department, the screening programme was conducted by one optometrist who was the principal investigator.

Conclusion

The project showed feasibility to screen for DM and DR in a district health setting of SA. The screening model demonstrated improvement in quality of care of patients with DM and confirmed the importance and relevance of screening patients with DM to prevent development and progression of DR.

Recommendations

There should be more commitment from data capturers to organise databases for all patients with chronic illnesses. They should also capture more than one contact number of patients so that family members can be contacted if patients do not follow their review appointments. This will ensure better control and efficiency in follow-up to manage patients with DM. The involvement of community health workers will be beneficial to assist with patient recruitment and education on the importance of being tested for DM. This can be done by arranging campaigns highlighting symptoms and the associated complications of DM. The involvement of dieticians to assist and train PHC nurses to calculate BMI and educate patients on the importance of following proper meal plans will also be beneficial. Measuring scales and meter rulers for height assessment must be available at the clinics to determine BMI for obesity detection. The importance of blood testing should be emphasised to patients so that they see the need to be assessed for complications associated with DM. Furthermore, PHC nurses are to ensure that testing supplies are available and in good working condition for patient care at clinics, that is, blood pressure machines, glucometers, spare batteries and various blood testing tubes. Remodelling of clinics to create more working space and larger patient waiting areas will ensure more efficiency in the workplace. Staff recruitment needs to happen so that the DR screening model can be implemented by a team of HCPs dedicated to the programme.

The main aim in primary care is not to reach a specific diagnosis but to detect patients who are eligible for referral to be further managed. Healthcare practitioners (HCP) have to develop confidence in managing patients with DM and this can be achieved by engaging in group discussions with other HCPs, and by attending training courses for updates in management strategies and cascading information to other

team members. Training programmes in retinal photography need to be introduced for optometrists and ophthalmic nurses working in the public sector especially because the use of non-mydriatic retinal photography has proven to be cost-effective in the DHS of SA.[38] Automated computer analysis of digital fundus images using smartphone would be a useful tool to enhance manual analysis by various HCPs.[39] If the screening protocol is to be effectively implemented then all posts for optometrists and ophthalmologists need to be filled and posts for ophthalmic nurses in each district hospital need to be created. The continuation of the screening programme is dependent on various stakeholders at provincial and national level to incorporate this programme officially under the chronic management disease programme. This will, however, require essential resources to support the screening model.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

Z.A. was project leader, developed the protocol, collected and captured data, wrote up the research and prepared the draft for publication. K.N. and L.V. reviewed content of questionnaires for applicability, construct validity and reliability and provided guidance as supervisors to the write-up of the research thesis.

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Data availability statement

The data collected will be used solely for the purposes of completing my (Z.A.) research thesis and in future articles, journal articles and books that will be written by the author (Z.A.).

Additional information is available upon reasonable request from the corresponding author.

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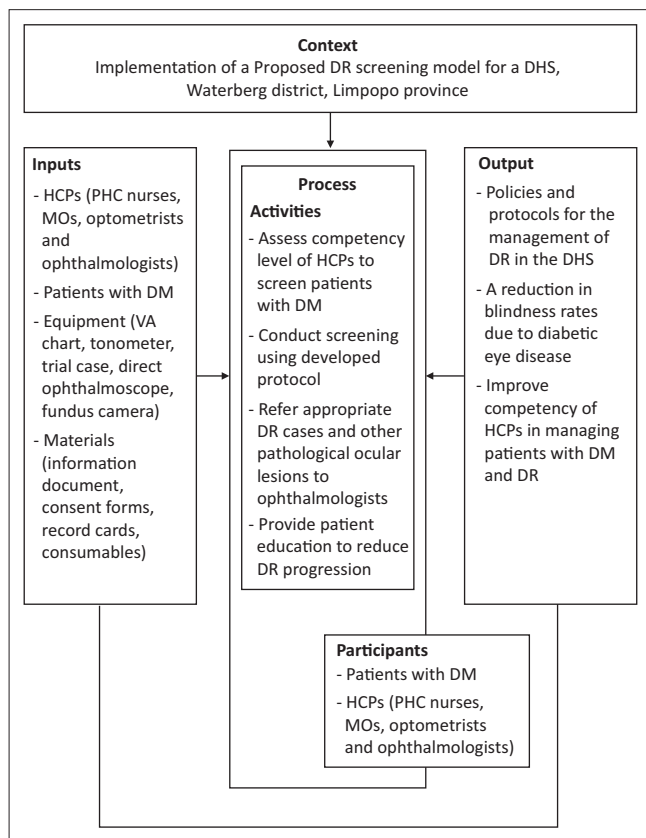
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Appendix 1

Context-input-process-output approach model

Context

Implementation of a Proposed DR screening model for a DHS, Waterberg district, Limpopo province

Inputs

- HCPs (PHC nurses, MOs, optometrists and ophthalmologists)
- Patients with DM
- Equipment (VA chart, tonometer, trial case, direct ophthalmoscope, fundus camera)
- Materials (information document, consent forms, record cards, consumables)

Process

Activities

- Assess competency level of HCPs to screen patients with DM
- Conduct screening using developed protocol
- Refer appropriate DR cases and other pathological ocular lesions to ophthalmologists
- Provide patient education to reduce DR progression

Output

- Policies and protocols for the management of DR in the DHS
- A reduction in blindness rates due to diabetic eye disease
- Improve competency of HCPs in managing patients with DM and DR

Participants

- Patients with DM
- HCPs (PHC nurses, MOs, optometrists and ophthalmologists)

HCPs, healthcare practitioners; PHC, primary healthcare; MOs, medical officers; DM, diabetes mellitus; VA, visual acuity; DR, diabetic retinopathy; DHS, district health systems.