Prevalence of diabetic retinopathy in self-reported diabetics among various ethnic groups and associated risk factors in North-East India: A hospital-based study

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Purpose: To describe the prevalence and severity of diabetic retinopathy (DR) among different ethnic groups of North-East India and to study the associated risk factors. **Methods:** In this hospital based cross sectional study 7,133 individuals among the age group of 20-79 years, attending the OPD, were screened for presence of Diabetes Mellitus (DM) (HbA1c >7% or previously diagnosed). Among them, 780 (10.94%) had diabetes; they were evaluated for presence of any retinopathy (based on fundus photograph and fluorescein angiography), its grade (based on International DR severity scale), and risk factors. DR patients were further grouped into different ethnicities (Assamese, Bengali, minor tribes, and other immigrants). **Results:** Of the 780 patients with diabetes, 58 patients had type 1 DM and 722 patients had type 2 DM. The overall prevalence of DR was 30.0% with vision-threatening retinopathy and maculopathy being 10.00% and 4.49%, respectively. The prevalence of retinopathy range was the highest in the immigrants' group (50.00% among type 1 DM and 44.93% among type 2 DM) and lowest in the tribal's groups (16.67% among type 1 DM and 22.35% among type 2 DM). The risk factors showing significant association with DR were longer diabetes duration, older age, family history of diabetes, higher HbA1c level, associated hypertension, hypertriglyceridemia, and pregnancy state (*P* value <0.05). **Conclusion:** Every third patient with diabetes had some form of DR with Vision Threatening DR (VTDR) affecting every tenth patient. There was also a wide variation in the prevalence of DR among ethnic groups and this difference could not be attributed to variation in the known measurable risk factors among different ethnic groups, thus signifying the role of ethnicity in occurrence and severity of DR.

Key words: Diabetic retinopathy, ethnic variation in DR, prevalence, vision threating diabetic retinopathy

Diabetes Mellitus (DM) is a chronic metabolic disease characterized by hyperglycemia as a result of defects in insulin secretion or action. The disease has acquired the global pandemic status and its worldwide prevalence is estimated to be 463 million in year 2019. The prevalence is predicted to rise to 700 million worldwide by 2045.[1]

Diabetic Retinopathy [DR] is one of the most common microvascular complications in patients with Diabetes and it is the leading cause of visual impairment. Population-based studies suggest that one-third of the diabetic patients have signs of DR and one-tenth have vision-threatening states of DR, such as Diabetic Macular Edema [DME] and Proliferative Diabetic Retinopathy [PDR].[2] The incidence of DR in Type 1 Diabetes (T1DM) is 71-90%, whereas in Type 2 Diabetes (T2DM) it is around 67% after 10 years of onset of diabetes.[3]

The worldwide prevalence of DR and PDR is estimated to be 35.4% and 7.5%, respectively, based on a previous pooled individual participant meta-analysis conducted worldwide a decade ago involving 35 studies from 1980 to 2008.[4] Globally,

it is estimated that there are 93 million people with DR out of which 17 million are of proliferative DR (PDR), 21 million with macular edema, and 28 million with sight-threatening DR.[4] New meta-analysis of pooled studies included till March 2020 estimated the global prevalence of DR to be 22.27% with 6.17% and 4.07% of VTDR and CSME, respectively.[5] It showed the highest pooled prevalence of DR (35.90%) and prevalence of VTDR (14.36%) in Africa.[5]

The major risk factors contributing to development and severity of DR among patients with diabetes are duration of diabetes, glycemic control, co-existing diabetic complications, and other associated conditions: Hypertension, carotid artery occlusive disease, anemia, pregnancy, and family history of retinopathy.[6]

Data from various studies suggested the association of ethnicity and other regional factors such as urbanization to development of DR besides the proven risk factors.[7-9]

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A breakdown of the prevalence rates of DR geographically and ethnically provides us with a vision of a region's future needs. In India, few studies like Raman *et al.*[10] S S Gadkari *et al.*,[11] and Azad *et al.*[12] were conducted regarding the prevalence of DR among diabetic patients.

Ethnic groups with variations in life style and eating habits reside in North-East India. People residing in Assam can be broadly grouped into four categories based on their ethnicity: Assamese, Bengalis, Tribals, and Immigrants from other parts of India. Common tribal groups prevalent in Assam are Ahom, Bodo, Manipuri, Karbi, Naga, Mishing, Mizo, and others.[13] Because of the difference in living styles in these ethnic groups, study among this population will provide a good knowledge about the association of ethnicity with prevalence of DR.

This study aims to evaluate the prevalence and severity of DR and the major risk factors associated with it among self-reported people of diabetes belonging to four major ethnic groups attending the Tertiary Care Center in North-East India.

Methods

Study design and population

This was a prospective observational study conducted at a tertiary care center in North-East India (Regional Institute of Ophthalmology, Gauhati Medical College and Hospital) to estimate the prevalence of DR among self-reported individuals with diabetes in relation to risk factors. The study adhered to the Declaration of Helsinki, and ethics approval was obtained from the Institute Institutional Review Board.

All individuals of DM (Type 1 and Type 2) in the age group of 20–79 years attending the OPD from August '16–July '17 and willing to give informed consent were included. Conditions mimicking DR – hypertensive retinopathy, retinal vascular occlusion, traumatic macular edema, age-related macular degeneration, choroidal neovascularization, other causes of macular edema, and media opacity obscuring fundus evaluation were excluded. Patients with severe renal insufficiency and cardiovascular dysfunction, in which thorough evaluation was not possible, were excluded [Fig. 1].

A total of 7133 patients attending the OPD from August '16 to July '17 were screened for the presence of diabetes. Out of these, 780 people were diagnosed with diabetes and these individuals were further evaluated for the presence of DR and associated risk factors. A detailed history including disease duration, diabetes type (type I or II), family history, smoking, and associated systemic diseases like hypertension, anemia, pregnancy, and nephropathy was documented on the basis of a predefined proforma. The different ethnic groups of these patients were categorized into four major groups for evaluation purposes (Native Assamese, Bengali, tribal and Inhabitant immigrants) and tribal group was further sub-categorized into Bodo, Manipuri, Karbi, Naga, Mising, and Mizo group.

All patients were subjected to systemic and ocular examination. 7-field Fundus Photography of all DR patients were recorded using the Zeiss Visucam Fundus Photograph camera after full dilatation and the fundus picture was analyzed for classification of DR and DME by the principle investigator (HVS). Optical coherence tomography imaging was performed for assessing macular edema using the Stratus
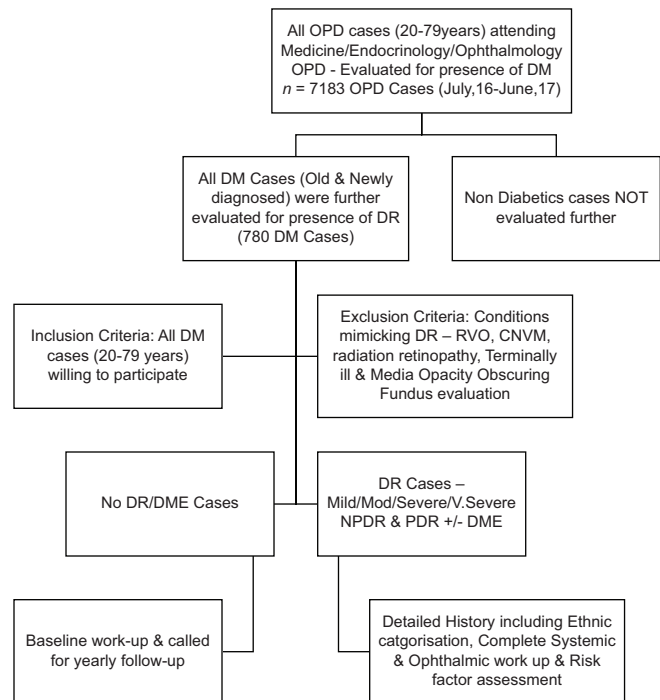
Figure 1: Flow Chart showing study design

OCT (Carl Zeiss Meditec Inc., Dublin, California, USA) using 6-mm radial lines (oriented 30 degree apart) to delineate macular anatomy and pathology. Results relevant to this study were categorized into – A. Demographic profile of Diabetes, B. Prevalence and Demographic profile of DR, C. Risk factors associated with DR, and D. Ethnic variability in occurrence of Retinopathy.

Ethnic groups' categorization[13]

All patients with diabetes were classified into four ethnic groups – Assamese, Bengalis, Tribals, and other immigrant groups from different parts of India, mostly from Bihar, Orissa, Rajasthan, and Punjab. The tribal populations were further grouped into Bodo, Manipuri, Karbi, Mising, Naga, and Mizo tribes.

Diabetic retinopathy definition and assessment

In this study, DR is defined according to the American Association of Ophthalmology International Clinical Diabetic Retinopathy Disease Severity Scale.[14] In the present study, DR represents any DR, including VTDR and CSME. Vision-threatening DR was defined as the presence of severe nonproliferative DR, proliferative DR, CSME, or a combination thereof according to the Eye Diseases Prevalence Research Group definition.[15] Clinically significant macular edema was defined as (1) thickening of the retina at or within 500 mm of the center of the macula, (2) hard exudate at or within 500 mm of the center of the macula associated with thickening of adjacent retina, or (3) a zone of retinal thickening 1-disc area or larger, any part of which is within 1-disc diameter of the center of the macula according to the Early Treatment Diabetic Retinopathy Study definition.[9]

Statistical analysis

Collected information were analyzed on SPSS version 16.0 in two parts:

1. Descriptive Analysis: Percentages, Proportions, Mean, and Standard Deviations.
2. Inferential Analysis: Unpaired t-tests, Chi-square, and binary logistic regression.

Prevalence of retinopathy in subgroups was compared by Chi-square test. *P* value was calculated using Fischer's exact test. To find the correlation between the variables, Pearson's correlation of coefficient was applied. A *P* value of less than 0.05 was considered to be statistically significant.

Results

A total of 7133 patients were screened for diabetes, of which 780 people had diabetes with prevalence of 10.94% (aged 20–79 years, noncritically ill, and willing to participate in the study). The proportion of type 1 DM and type 2 DM among people with diabetes were 7.5% and 92.5%, respectively. The mean age of the diabetics was 47.68 years (SD - 11.77 years) with maximum patients in the age group of 40–49 years (34.4%) of which, 475 were males (60.10%) and 305 were females (39.10%) with slight male preponderance (1.54:1). The mean age of presentation of type 1 DM was 33.10 ± 8.21 yrs whereas that of type 2 DM was 48.85 ± 11.20 years. A total of 133 people (17.05%) had a history of disease duration of less than 6 months and were categorized as newly diagnosed DM. Most of the diabetics predominantly belonged to the urban population (85%).

About 234 out of 780 diabetic patients (30.00%) showed signs of DR. Prevalence of DR among type 1 diabetes were higher compared to type 2 diabetes (36.21% among type 1 vs. 29.50% among type 2 diabetes). Age-wise distribution of DR in type 1 diabetes shows maximum prevalence of DR in the age group of 50–59 years followed by age group 40–49 years with mean age of presentation of DR as 36.67 ± 7.96 years. The mean age of presentation of DR in type 2 DM was 57.04 ± 11.46 years with maximum prevalence in the age group of more than 70 years. The mean age of presentation of VTDR (Severe, Very severe NPDR, and PDR with or without CSME) was 42.5 ± 4.63 years among type 1 and 63.43 ± 8.66 years among type 2 diabetes and the prevalence of any form of DR was 38.10% and 32.86% among type I and type II DM respectively. The prevalence of DR was slightly higher in rural population (34.19%) than in urban

population (29.26%), but the difference was not statistically significant. Out of 133 newly diagnosed diabetics, prevalence of DR were significantly lower when compared with already diagnosed diabetics; prevalence of DR was 13.53% versus 33.38%.

In the study, DR patients were further categorized into four major groups – Assamese, Bengalis, Tribal, and Others-immigrants from other parts of India. Tribal were further sub-categorized into Bodo, Manipuri, Karbi, Naga, Mishing, and Mizo tribes. Prevalence of DR was the highest among immigrant group with a prevalence of 50% and 44.93% among type 1 DM and type II DM, respectively. Prevalence of DR was significantly low in tribal groups with a prevalence of 16.67% and 21.59% among type I and II DM, respectively. Among tribal groups, maximum prevalence of DR was observed in Naga group (30.00%) and Mishing group had a minimum prevalence of DR (15.38%).

Linear regression analysis for association of various risk factors with presence of DR showed significant association with longer disease duration in DR group, poor glycemic control, higher mean systolic blood pressure, and positive family history of diabetes. Howerver, conditions like smoking, anemia, and pregnancy showed no clinically significant association with presence of DR changes.

Discussion

This is a first hospital-based study conducted in North-East India to evaluate the proportion of DR among self-reported diabetic patients. It evaluated various risk factors associated with the presence of DR among diabetics and also calculated the variation in DR occurrence among them.

Demographic profile

The mean age and sex distribution of diabetic population was comparable with studies Gale *et al*.[16] and Nayak *et al*.[17] The prevalence of DR among diabetics was also comparable to numerous studies,[18,19] but CURES study[20] showed a lower prevalence that can be attributed to smaller sample size in our study and referral bias associated with the present hospital-based study. The mean age of diabetic patients with and without DR changes was 55.2 years (SD 12.6 yrs.) and 44.4 years (SD +/- 9.7 years), respectively, which was
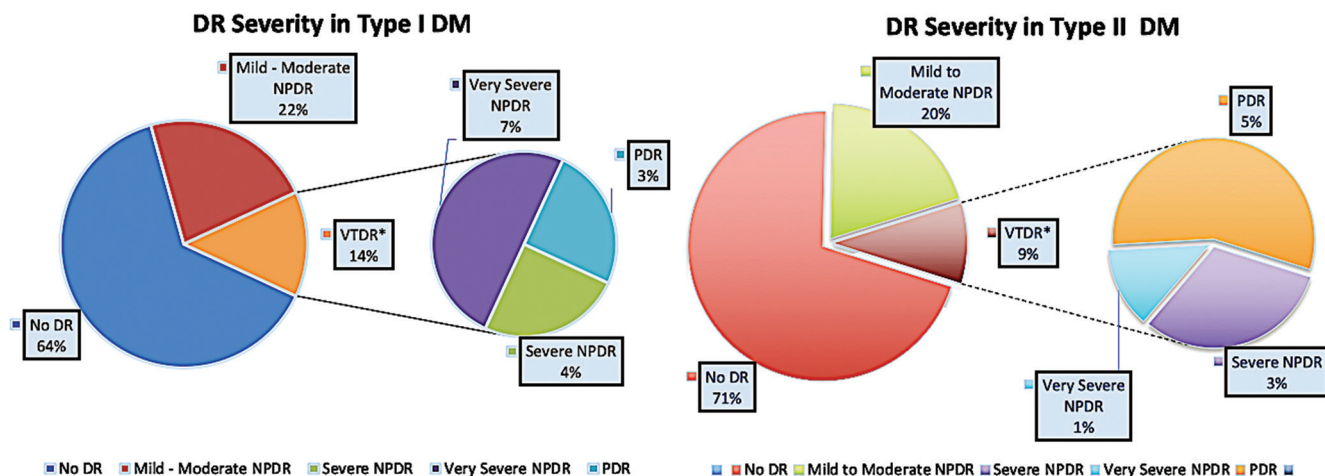

Figure 2: Prevalence of DR, VTDR* in study population

comparable to data provided in studies by Raman *et al.*[10] and Mohan *et al.*[15] Although these results were consistent, there was a wide variation in the estimated prevalence of DR among the various age groups when taken into count separately, the reasons of which might be because of different ratios of Type 1 and Type 2 DM among studies, variation in level of glycemic control, blood pressure and other systemic parameters, and also variation in ethnicity.[10,21]

Prevalence of VTDR with DM

The mean age of patients with VTDR was 63.5 years among type 2 DM and 42.5 years among type 1 DM. The overall prevalence of VTDR in the present study was 9.14%. Raman *et al.*[10] in their study SN-DREAM II reported age-wise increase in the prevalence of VTDR with mean age of presentation of VTDR to be 67.0 yrs. in all types of diabetes. The overall prevalence of VTDR in their study was 7.1%[22] [Fig. 2].

Duration of DM and association of DR

The present study showed increase in the prevalence of DR with duration of disease, which was consistent with various other studies. The mean duration of diabetes among patients with presence of DR changes was 8.095 ± 4.867 years among type 1 diabetes and 7.16 ± 5.05 years among type 2 diabetes [Table 1]. Whereas mean duration of diabetes among diabetic people with no retinopathy changes was 5.517 ± 4.928 years among type 1 diabetes and 3.788 ± 4.494 years among type 2 diabetes. In this study, the prevalence of DR among type 1 DM increases from 15.0% in subjects with duration of diabetes less than 5 years to 80.0% in subjects with duration of diabetes more than 15 years. Similarly, among type 2 DM, the prevalence of DR increases from 13% in individuals with diabetes ≤5 years to 80% among individuals with diabetes ≥15 years. Similar increase in diabetic prevalence was noted in various national and international studies.[3,19,23]

Glycemic control and DR

Our study showed strong association between poor glycemic control and presence of DR among both type 1 DM and type 2 DM group similar to the other studies.[22-25] The mean blood sugar of VTDR was 11.1 mmol/dl HbA1C (RBS 209.14 with SD of 56.39 mg/dl), whereas those in the nonVTDR group had the mean blood glucose as 7.8 mmol/dl (RBS 143.25 with SD of 62.36 mg/dl).

Table 1: Baseline Characteristics and DR prevalence in study population (Refer to Annexure I for Definitions)

Variables	Diabetic retinopathy (*N*=234)	No Diabetic retinopathy (*n*=546)	*P* value	Odd Ratio
Age (years)	55.21±12.61	47.68±11.77	0.0001	-
Duration of diabetes (years)	7.24±5.04	4.82±5.02	0.0010	-
Poor Glycemic status*	161	154	0.0012	4.17
Systolic B.P.#	113	91	0.0001	4.94
Diastolic B.P.##	152	149	0.0010	5.96
Smoking	17	47	0.5720	0.83
Anemia**	22	41	0.2450	0.39
Microalbumiuria$	36	44	0.0003	2.07

*HbA1c >7 mg/dl – Poor glycemic status, #Systolic hypertension >130 mmHg, ##Diastolic Hypertension >90 mmHg, **Anemia: Hb <11.5 gm/dl in females, and <13 gm/dl in males; $Microalbuminuria >300 mg/24 hr. B.P: Blood Pressure

Table 2: Multiple logistic regression analysis with diabetic retinopathy as a dependent variable in normoalbuminuric people with type 1 and 2 diabetes mellitus

Variables	Diabetics (*N*=780)	Diabetic retinopathy (*N*=234)	Type I DM (*n*=58)		Type II DM (*n*=722)		*P* value
			No retinopathy (*n*=37)	Diabetic retinopathy (*n*=21)	No retinopathy (*n*=509)	Diabetic retinopathy (*n*=213)	
Age (years)	47.68±11.77	55.21±12.61	31.08±7.74	36.67.08±7.96	45.42±9.18	57.04±11.46	<.0001
Duration of diabetes (years)	4.82±5.02	7.24±5.04	5.52±4.87	8.10±4.93	3.79±4.49	7.16±5.05	0.0001
Females	302	95	16	9	191	86	0.92
Newly diagnosed#	133	18	39	7	76	11	0.234
Rural	117	40	21	11	56	29	<.0001

#Newly diagnosed – Diabetes with disease duration not more than 6 months

Table 3: Estimated DR proportion among various ethnic groups of Assam

Ethnic groups	Total DR among Type 1 DM	Total DR among Type 2 DM	DR Prevalence (percentage)
Assamese	09/25 (36.0%)	88/321 (27.4%)	28.00%
Bengalis	07/19 (36.84%)	75/247 (30.36%)	30.83%
Tribals	01/06 (16.67%)	19/85 (22.35%)	21.98%
Others (Immigrants)	04/08 (50%)	31/69 (44.93%)	46.67%

Table 4: Estimated DR proportion among various tribal groups of North-East India

Tribal group	DR	Total DM (Type 1 and 2)	Prevalence of DR (percentage)
Bodo	6	27	22.22%
Manipuri	3	15	20.00%
Karbi	4	16	25.00%
Naga	3	10	30.00%
Mising	2	13	15.38%
Mizo	2	10	20.00%
Total	20	91	21.98%

Newly diagnosed diabetics and DR

Our study reported a prevalence of DR among recently diagnosed individual of DM (with disease duration less than 6 months) to be 13.53%, whereas the prevalence was 33.38% among known diabetics. Klein et al.[3] showed the prevalence of DR to be 6% in newly detected diabetes.[26] Similarly, Lee R et al. in their study reported the prevalence of DR in newly detected DM to be 8%.[2,4] The CURES reported the prevalence of 20.80% in known diabetics and 5.1% in newly detected diabetes.[20] The possible reasons for higher prevalence in our study could be because of smaller sample size of newly diagnosed diabetes and variation in criteria of recent onset diabetes in different studies.

The prevalence of DR among rural and urban population was 34.19% and 29.26%, respectively. But, the difference in prevalence of retinopathy was not significant [Table 2].

The present study showed significant correlation of severity of DR with various other risk factors like uncontrolled blood pressure (P value = 0.0294), dyslipidemia (P value = 0.0002), nephropathy (P value = 0.0029), and family history of diabetes (P value = 0.0002), whereas no significant association was established with smoking habits, anemia, and pregnancy [Table 2].

Variation of DR among ethnic groups

The prevalence of DR varied from 21.59% in tribal group to 44.93% in other immigrant population among type 2 diabetes. Similar trend was noted among type 1 diabetes with tribal group having 16.67% whereas the prevalence among immigrant group was 50.00%. [Table 3]. The severity of DR also varied among major ethnic groups with a maximum prevalence of VTDR seen in the Immigrants group (23.4%) whereas prevalence of VTDR among Assamese (6.36%), Bengalis (9%), and tribal groups (10.9%) were almost similar.

The prevalence of DR also varied among major tribal population with prevalence highest among Naga group and lowest among Mising group [Table 4]. The severity of DR was also noted to be more in Naga group as compared to other tribal groups.

Low prevalence of DR among tribal population could be attributed to causes like
1. Good dietary habits with major proportion of raw and boiled foods in their diet.
2. Life style (because of lack of urbanization and hilly terrain, they are more indulged in outdoor activities rather than a sedentary life style).

3. Genetic variability could have important contribution to low prevalence of DR.

Similarly, higher prevalence of DR among Immigrants population from other parts of India could be explained partly by rapid urbanization and changing life-style condition. Various studies including VADT-2005 Study,[27,28] Rebecca Thomas et al.,[29] C H Tan et al.,[30] and DRIVE-UK Study.[4,31] have already demonstrated worldwide variation in prevalence of DR in various ethnic groups. Raman et al.[10,22] and Rema et al.[20] have demonstrated ethnic variation in prevalence of DR in India. The authors in this study believe that the wide range of prevalence of DR in ethnic groups in different studies might be due to:
1. Variation in criteria for diagnosis of diabetes:
   a. Self-reported
   b. Oral glucose tolerance test
   c. Fasting blood glucose with various cut points
   d. Random blood glucose with various cut points
   e. HbA1c
2. Duration of DM among studies (generally longer in developed countries).
3. Technical variations like number of fundus photographic fields used for detection and staging of retinopathy.
4. Genetic components inherent in ethnic variations.

Conclusion

The present study reported the proportion of DR among self-reported individuals of diabetes to be one-third with slightly higher among type 1 DM than type 2 DM. Age of presentation was an important determining factor for the presence of DR in this study. The prevalence among rural population was slightly higher than the urban counterpart. But the difference was not significant. The overall prevalence of DR was higher when compared with other Indian studies, which may be because of referral bias as the present study is a hospital-based prospective study conducted in a tertiary health care center. Significant variation in the prevalence was observed among different ethnic groups that cannot be attributed to variation in the known measurable risk factors among these ethnic groups. Thus, the role of ethnicity in occurrence and severity of DR cannot be rule out. The prevalence of DR was the highest among immigrant population and the lowest among tribal population probably because of differences in their lifestyle and food habits.

The risk factors like duration of diabetes, glycemic control, systolic blood pressure, family history, and diabetic nephropathy showed strong association with presence of DR. But, no significant association was found between DR and risk factors like pregnancy, anemia, socio-economic status, and diastolic blood pressure.

Study limitations

The study had some limitations also. It was a hospital-based cross-sectional study in tertiary care center leading to higher than expected proportion of DR among self-reported diabetics. The sample size among sub-categories of ethnic groups were smaller and the variation of known risk factors among these groups were not evaluated in the present study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, *et al.* Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International diabetes federation diabetes atlas, 9 edition. Diabetes Res Clin Pract 2019;157:107843.

2. Lamoureux EL, Wong TY. Diabetic retinopathy in 2011: Further insights from new epidemiological studies and clinical trials. Diabetes Care 2011;34:1066-7.

3. Klein R, Klein BE, Moss SE, Cruickshanks KJ. The Wisconsin epidemiologic study of diabetic retinopathy. XIV. Ten-year incidence and progression of diabetic retinopathy. Arch Ophthalmol 1994;112:1217-28.

4. Lee R, Wong TY, Sabanayagam C. Epidemiology of diabetic retinopathy, diabetic macular edema and related vision loss. Eye Vis (Lond) 2015;2:17.

5. Teo ZL, Tham Y-C, Yu M, Chee ML, Rim TH, Cheung N, *et al.* Global prevalence of diabetic retinopathy and projection of burden through 2045: Systematic review and meta-analysis. Ophthalmology 2021;S0161-6420(21)00321-3. doi: 10.1016/j.ophtha.2021.04.027. Online ahead of print.

6. Yau JW, Rogers SL, Kawasaki R, Lamoureux EL, Kowalski JW, Bek T, *et al.* Global prevalence and major risk factors of diabetic retinopathy. Diabetes Care 2012;35:556-64.

7. Bonney M, Hing SJ, Fung AT, Stephens MM, Fairchild JM, Donaghue KC, *et al.* Development and progression of diabetic retinopathy: adolescents at risk. Diabet Med 1995;12:967-73.

8. Ginsburg LH, Aiello LM. Diabetic retinopathy: Classification, progression, and management. Focal Points: Clinical Modules for Ophthalmologists. San Francisco: American Academy of Ophthalmology; 1993. module 7.

9. Davis MD, Fisher MR, Gangnon RE, Barton F, Aiello LM, Chew EY, *et al.* Risk factors for high-risk proliferative diabetic retinopathy and severe visual loss: Early treatment diabetic retinopathy study report 18. Invest Ophthalmol Vis Sci 1998;39:233-52.

10. Raman R, Ganesan S, Pal SS, Kulothungan V, Sharma T. Prevalence and risk factors for diabetic retinopathy in rural India. Sankara Nethralaya diabetic retinopathy epidemiology and molecular genetic study III (SN-DREAMS III), report no 2. BMJ Open Diabetes Res Care 2014;2:e000005.

11. Gadkari SS, Maskati QB, Nayak BK. Prevalence of diabetic retinopathy in India: The All India ophthalmological society diabetic retinopathy eye screening study 2014. Indian J Ophthalmol 2016;64:38-44.

12. Azad R, Kumar A, Tewari HK. Diabetic non diabetic maculopathy-A new entity. Indian J Ophthalmol 1990;38:7-9.

13. Available from: https://easternroutes.com/northeast-india/assam/tribes. [Last accessed on 2021 Sep 28].

14. Wilkinson CP, Ferris FL 3rd, Klein RE, Lee PP, Agardh CD, Davis M, *et al.* Proposed international clinical diabetic retinopathy and diabetic macular edema disease severity scales. Ophthalmology 2003;110:1677-82.

15. Mohan V, Vijayprabha R, Rema M. Vascular complications in long term South Indian NIDDM of over 25 years duration. Diabetes Res Clin Pract 1996;31:133-40.

16. Gale J. India's Diabetes Epidemic Cuts Down Millions Who Escape Poverty. Bloomberg news. November 7, 2010. Available from: URL: http://www.bloomberg.com/news/2010-11-07/india-s-deadly-diabetes-scourge-cuts-down-millions-rising-to-middle-class.html. [Last accessed on 2021 Sep 28].

17. Nayak HK, Vyas S, Solanki A, Tiwari H. Prevalence of type 2 diabetes in urban population of Ahmedabad, Gujarat. India J Med Specialities 2011;2:101-5.

18. Melmed S, Polonsky KS, Larsen PR, Kronenberg HM. Williams Textbook of Endocrinology. 12th ed. Philadelphia: Elsevier/Saunders; 2011. p. 1371-435.

19. Gupta S, Ambade A. Prevalence of diabetic retinopathy and influencing factors amongst type II diabetics from Central India. Int J Diabetes Dev Ctries 2004;24:75-8.

20. Rema M, Premkumar S, Anitha B, Deepa R, Pradeepa R, Mohan V. Prevalence of diabetic retinopathy in urban India: The Chennai urban rural epidemiology study (CURES) eye study, I. Invest Ophthalmol Vis Sci 2005;46:2328-33.

21. Kempen JH, O'Colmain BJ, Leske MC, Haffner SM, Klein R, Moss SE, *et al.* The prevalence of diabetic retinopathy among adults in the United States. Arch Ophthalmol 2004;122:552-63.

22. Raman R, Rani PK, Reddi Rachepalle S, Gnanamoorthy P, Uthra S, Kumaramanickavel G, *et al.* Prevalence of diabetic retinopathy in India: Sankara Nethralaya diabetic retinopathy epidemiology and molecular genetics study report 2. Ophthalmology 2009;116:311-8.

23. Yanko L, Goldbourt U, Michaelson IC, Shapiro A, Yaari S. Prevalence and 15-year incidence of retinopathy and associated characteristics in middle-aged and elderly diabetic men. Br J Ophthalmol1983;67:759-65.

24. Diabetes Control and Complications Trial Research Group, Nathan DM, Genuth S, Lachin J, Cleary P, Crofford O, *et al.* The effect of intensive treatment of diabetes on the development and progression of long-term complications in IDDM. N Engl J Med 1993;329:977-86.

25. UK prospective diabetes study (UKPDS) group. Intensive blood glucose control with sulfonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet 1998;352:837-53.

26. Klein R, Klein BE, Moss SE, Davis MD, DeMets DL. Is blood pressure a predictor of the incidence or progression of diabetic retinopathy? Arch Intern Med 1989;149:2427-31.

27. Duckworth W, Abraira C, Moritz T, Reda D, Emanuele N, Reaven PD, *et al.* Glucose control and vascular complications in veterans with type 2 diabetes. N Engl J Med 2009;360:129-39.

28. Emanuele N, Sacks J, Klein R, Reda D, Anderson R, Duckworth W, *et al.* Ethnicity, race, and baseline retinopathy correlates in the veterans affairs diabetes trial. Diabetes Care 2005;28:1954-8.

29. Thomas RL, Distiller L, Luzio SD, Chowdhury SR, Melville VJ, Kramer B, *et al.* Ethnic differences in the prevalence of diabetic retinopathy in persons with diabetes when first presenting at a diabetes clinic in South Africa. Diabetes Care 2013;36:336-41.

30. Tan CH, Lai YK. Characteristics of diabetic retinopathy patients at initial presentation. Med J Malaysia 1996;51. p. 188-192.

31. Sivaprasad S, Gupta B, Gulliford MC, Dodhia H, Mohamed M, Nagi D, *et al.* Ethnic variations in the prevalence of diabetic retinopathy in people with diabetes attending screening in the United Kingdom (DRIVE UK). PLoS One 2012;7:e32182.

Annexure: Criteria for the Different Parameters in the Study

Criteria for the diagnosis of DM.

Patients fulfilling the following criteria were categorized as diabetic subjects:
- Glycosylated hemoglobin/HbA1C level more than 7.0%,
- Fasting Plasma Glucose (FPG) more than or equal to 126 mg/dL, or
- 2-hour PostPrandial Glucose more than or equal to 200 mg/dL, or
- Any patient with a history of Diabetes on Treatment.

Type of Diabetes:

Based on Royal College of General Practitioners guidelines 2011:
A. Subjects with following criteria were grouped as type 1 DM
- Diagnosed at age less than 35 years AND continual insulin treatment within 6 months of diagnosis.
- Diagnosed at age of more than or equal to 35 years AND continual insulin treatment from diagnosis. AND

B. Subjects not fulfilling the above criteria were grouped as type 2 DM.

Severity of DR:

Based on International Clinical Diabetic Retinopathy Disease Severity Scale, DR was classified into No apparent retinopathy, Mild NPDR, Moderate NPDR, Severe NPDR, very severe NPDR, and PDR groups.

Criteria/goals of Ideal glycemic control:

Ideal glycemic control includes
- Hemoglobin A1c is below 7.0 mmol/l,
- Fasting plasma glucose less than 126 mg/dl,
- Peak postprandial glucose less than 180 mg/dl.

Criteria for hypertension:
- When systolic BP >140 mm Hg and/or Diastolic BP >80 mm Hg (according to JNC – 8 classification),
- Or, current use of anti-hypertensive medications.

Criteria for diagnosis of Diabetic Nephropathy:

Diabetic Kidney disease (chronic kidney disease b/c of diabetes) is classified according to presence of
- Macroalbuminuria (more than 300 mg albumin/24 hours or ACR more than 34 mg/mmol [more than 300 mg/g]).
- Microalbuminuria (30-300 mg albumin/24 hours or Albumin to Creatinine ratio [ACR] of 3.4-34.0 mg/mmol [30-300 mg/g]) with – presence of DR OR type 1 diabetes of at least 10 years' duration.

Criteria for diagnosis of hyperlipidemia:

In this study, hyperlipidemia is defined according to the criteria set by adult treatment panel-III:
- Total cholesterol more than 200 mg/dl (5.2 mmol/l), and/or
- LDL cholesterol more than 100 mg/dl (2.6 mmol/l), and/or
- HDL cholesterol less than 40 mg/dl (1 mmol/l), and/or
- Triglycerides more than 150 mg/dl (3.9 mmol/l).

Criteria for diagnosis of anemia:
In this study, anemia is defined as hemoglobin concentration below 13 g/dl in male and below 11.5 g/dl in female.