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Estimating the need for diabetic retinopathy services in north India: evidence from a population-based survey in the catchment population of an eye care provider in central Uttar Pradesh

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ABSTRACT

Objective The aim of this study was to assess the prevalence of diabetic retinopathy (DR) and retina screening coverage among people with diabetes in the catchment area of a high-volume eye care organisation in north India.

Design A population-based cross-sectional study using Rapid Assessment of Avoidable Blindness survey, including the DR module.

Setting A customised rural district in the catchment of Dr Shroff's Charity Eye Hospital in Uttar Pradesh in north India.

Participants 4095 people of age 50 years and above were enrolled using a two-staged cluster sampling, 3867 (94.4%) participated; 2167 (52.9%) were women. 3803 of 4095 (92.9%) participants were assessed for diabetes. People with already diagnosed diabetes and anyone with a random blood glucose ≥200 mg/dL were offered dilated fundus examination.

Primary and secondary outcomes Primary and secondary outcomes were the prevalence of DR and screening coverage for DR, respectively.

Results The prevalence of diabetes was 7.0% (95% CI 5.9% to 8.0%). 50.2% of all people with diabetes were newly detected. The prevalence of any DR among people with diabetes who consented to dilated pupillary examination was 22.8% (51 of 224), (95% CI 18.2% to 27.3%). 5.8% (13/224) of people with diabetes were found to have sight-threatening DR and only 15.4% (2/13) had received treatment. 84.8% of people with previously diagnosed diabetes had never had their eyes tested for DR; this was significantly higher in women (90.2% vs 76.0%, respectively, p<0.001). 76% of people with previously diagnosed diabetes had poorly controlled diabetes; this was significantly higher for those on non-allopathic treatment (p<0.01). The odds of DR were higher with duration of diabetes >10 years and poor glycaemic control (OR of 1.8 and 1.6, respectively), but this was not found to be statistically significant.

Conclusion The prevalence of DR in this predominantly rural setting was found to be higher than the national average. Coverage of retinal screening and treatment was found to be very low. Working with general health providers to increase detection of people with diabetes and leveraging vision centres to improve DR screening coverage is needed in this region.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Rapid Assessment of Avoidable Blindness-Diabetic Retinopathy (RAAB-DR) is a standardised methodology for assessing the need for DR services in a region and we used the fully digitised RAAB7 data collection and management tool to enhance data quality.
- ⇒ Our study had a very high response rate, both for the RAAB survey and the DR module of the survey.
- ⇒ Retina screening coverage for DR is 1 of 13 core eye health indicators proposed by WHO in their Eye Care Indicator Menu.
- ⇒ As RAAB-DR is a planning tool, high-volume service providers can create 'customised districts' from their catchments for conducting RAAB-DR as done in this study, especially if the catchment does not conform to geo-political boundaries.
- ⇒ Sample size in RAAB is calculated for estimating prevalence, thus, it could have been inadequate for estimating statistical differences while conducting subgroup analyses.

BACKGROUND

According to the International Diabetes Federation, in 2021, 10.5% (537 million) of the world's adult population have diabetes with the number of cases disproportionately affecting low-income and middle-income countries. It is estimated that around 50%

of cases worldwide are undiagnosed, with the proportion of people with diabetes undetected also higher in low-income and middle-income countries than in high-income countries.[1] Uncontrolled diabetes can have adverse effects on vision, due to ocular conditions such as diabetic retinopathy (DR) which affected over 4.3 million people with diabetes worldwide in 2020.[2 3]

In India, it is estimated that 9.6% of adults have diabetes (over 74 million), with 53.1% undiagnosed.[4] In 2021, the prevalence of DR among people with diagnosed diabetes was found to be 12.5%,[5] implying much higher numbers when factoring in those remaining undiagnosed. The number of people with diabetes globally is expected to rise in the next few decades.[1] In India, 124 million people are predicted to be diabetic by 2045.[4] These increases in diabetes prevalence will lead to a corresponding increase in the number of people requiring eye care services for DR.

The Rapid Assessment of Avoidable Blindness (RAAB) survey methodology was developed to collect vision impairment (VI) data for the population aged 50 years and older.[6] While the RAAB method prioritises anterior segment diseases as causes of VI, there is an option to include a specific module to report on DR in greater detail (RAAB-DR).[7]

Dr Shroff's Charity Eye Hospital is a network of eye hospitals across north India, functioning on the pyramidal model of eye care delivery.[8] Uttar Pradesh (UP), the most populous state in the country,[9] is serviced by our organisation through five secondary surgical centres across five districts, and more than 60 vision centres (VCs). Recent data estimate the prevalence of diabetes in the state at 13.7%, with only 25% of the affected population aware of their condition.[10]

Our centre in Lakhimpur Kheri district is a rural hospital with seven VCs (at the time of this survey) serving a catchment of approximately 3.4 million people.[11] No previous RAAB-DR has been conducted here, and as service providers in the region, we aimed to use the RAAB-DR tool to assess the prevalence of DR and retina screening coverage in the catchment area of our centre to better plan service provision.

METHODS

Study design, setting and period

The study was a cross-sectional population-based survey of blindness and VI conducted between May and June 2022 in two neighbouring districts in UP: Lakhimpur Kheri (all-age population of around four million) and Shahjahanpur (all-age population of around three million).[11] Both districts have predominantly rural populations (figure 1).

We created a sampling frame which represented the catchment area serviced by our organisation through our surgical centre on the border of the two districts and its VCs. The sampling frame was made up of five blocks from Lakhimpur Kheri (Gola (Kumbhi), Bankeyganj, Mitauli, Mohammadi, Pasgawan) and three blocks from Shahjahanpur (Bhawal Khera, Khutar, Powayan) being served by seven VCs and the hospital. This customised 'district'

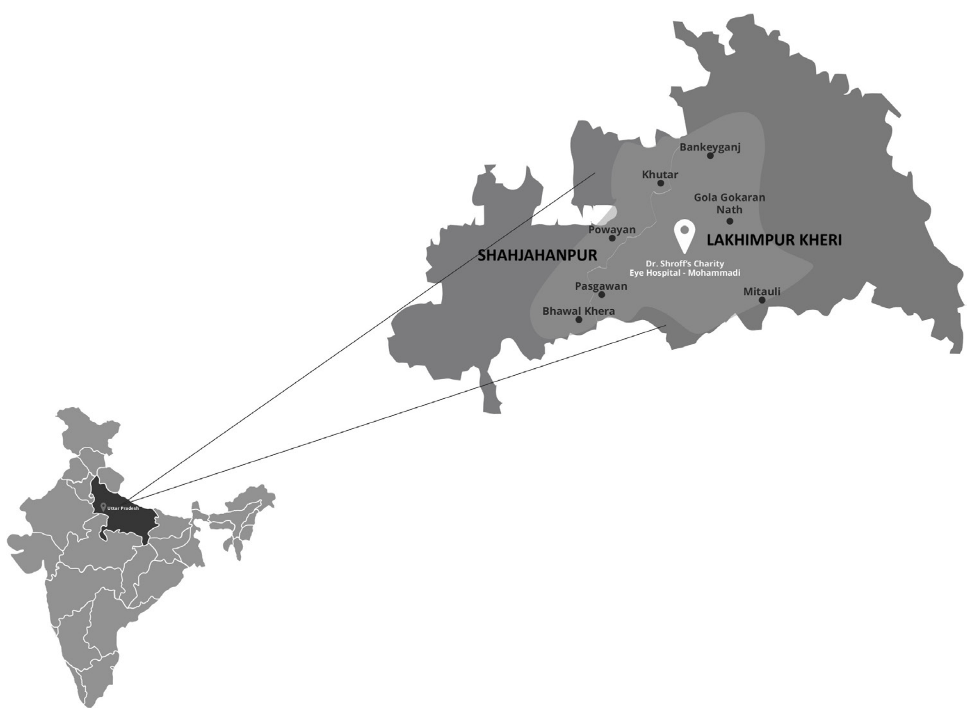

Figure 1 Geographical map of the setting where the study was conducted as a part of the districts in the state of Uttar Pradesh in India. Our hospital, on the cusp of the two districts: Shahjahanpur and Lakhimpur Kheri, is marked in white and the customised district (light gray) was created by combining the catchment of the hospital and the vision centres (marked as black dots) (original).

provided a catchment area covering around 2.03 million people.[11]

Inclusion and exclusion criteria

All people aged 50 years and older residing in their current location for at least 6 months prior to the survey were eligible for inclusion. Visitors and institutionalised populations were not eligible.

Sample size

A sample size of 4092 was calculated for the RAAB survey, using the RAAB7 software package based on an anticipated prevalence of blindness in people 50 years and older of 3.5%,[11] a design effect of 1.4 for a cluster size of 35, an estimated 10% non-response rate, a relative precision of 20% and a confidence level of 95%. The population aged 50 years and older was estimated at 406 914, assuming they made up 20% of the all-age population of 2 034 568 (2011 census population,[11] adjusted with decadal growth rate). As conventionally, the cluster size is fixed at 35 for RAAB DR, 4095, being the multiple of 35 closest to 4092, was finalised.

Sampling

The sample size was enrolled from 117 clusters of 35 persons aged 50 years and above. A two-stage cluster sampling strategy was used. At the first stage, 117 villages or wards were selected with probability proportionate to size using the RAAB7 software. At the second stage, 35 individuals were enrolled using a cluster segmentation approach.[7] A cluster informer visited the village a few days before the examination team arrived and worked with the village leaders to identify village borders. Once the segment boundaries were clear, the cluster informer updated the examination team and provided them with a copy of the map. Where a village population exceeded 400 all-age inhabitants, a map was drawn with the village leader to segment it into two or more segments of approximately equal population size containing 175 people overall and thus an estimated 35 people of age 50 years and above (estimated 20% of the entire population). One segment was chosen at random by picking up slips marked with the segment number. This was done in the presence of stakeholders in the village.

On the day of the study, the team met the village leader and nominated a guide. The study team then started at the house in the selected segment, closest to the road within the village and ascertained from the head of household the number of eligible people living in the household. All the households in the cluster on one side of the village road, both on the road and away, were covered before approaching the household on the other side. All were enumerated, including those temporarily absent, until 35 eligible participants were enrolled. The team attempted to revisit houses at the end of the day to capture anyone missing at the time of the initial visit.

Clinical examination

The team provided comprehensive information about the study and the purpose of their visit, followed by a discussion with the eligible participants regarding their right to refuse or withdraw permission to participate as well as the potential benefits of participation. All consenting participants underwent vision screening and ophthalmic examination by the ophthalmic members of the study team, as per the standard RAAB protocol.[7] Peek Acuity was used to carry out a distance vision assessment, measuring uncorrected visual acuity (VA) in both eyes, corrected VA in both eyes if a participant owned distance spectacles and pinhole VA in any eye where uncorrected or corrected VA was worse than 6/12. Presenting VA was taken as uncorrected VA or corrected VA according to the non-use or use of distance spectacles, respectively. Any eye with presenting VA less than 6/12 was examined to detect the main cause of poor vision and a principal cause of VI was also assigned to the person according to which right or left eye cause was more treatable or preventable. Any eye with presenting VA less than 6/12 with no obvious anterior segment or globe abnormality was dilated for examination of posterior segment. Minor ocular conditions identified were referred to the VC. Other conditions were referred to our secondary hospital in the region.

The DR module was done in line with the RAAB7 protocol.[7] All participants were asked if they had previously been diagnosed as diabetic and offered a random blood glucose test. This was tested using Oneplus No-coding Glucometer by Microsidd India. Those with previously diagnosed diabetes and/or random blood glucose level of 200 mg/dL or higher were offered dilated retinal examination. A separate informed consent was sought for blood glucose testing and pupillary dilatation. ‘People with previously diagnosed diabetes’ were those with an existing diagnosis of diabetes and ‘people with suspected diabetes’ were those without a previous diagnosis of diabetes but a random blood glucose level of 200 mg/dL or higher. People with previously diagnosed diabetes were asked about their duration and treatment for diabetes and when their most recent retina screening was done, if ever. RAAB-DR uses the Scottish DR Grading Scheme[12] to grade the level of retinopathy and maculopathy seen on dilated fundus examination with binocular indirect ophthalmoscopy. Fundus photography is not included in the examination protocol.

Data collection: training

Each of the three data collection teams consisted of four members: ophthalmologist (team leader), optometrist, cluster informer and a village guide. A qualified RAAB trainer conducted a 4-day training session covering RAAB procedures, interobserver variability tests and practical aspects to field work. Field staff were trained to uniformly follow the same procedure to identify eligible participants, assess visual acuity and conduct the lens examination. Standardised instructions (definitions, method of participation selection, examination protocol, and

Table 1 Distribution of participants tested for diabetes in the study

Diabetes status		Women n (%)	Men n (%)	Total n (%)
Total examined in RAAB survey		2167 (100.0)	1928 (100.0)	4095 (100.0)
Diabetes status assessed		2026 (93.5)	1777 (92.2)	3803 (92.9)
Total with diabetes		159 (7.8)	106 (6.0)	265 (7.0)
	People with previously diagnosed diabetes	82 (51.6)	50 (47.2)	132 (49.8)
	People with suspected diabetes (during RAAB)	77 (48.4)	56 (52.8)	133 (50.2)
Consented for dilated examination out of total diabetes		131 (82.4)	93 (87.7)	224 (84.5)

The numbers and percentages in each subsequent row are calculated based on the preceding main row.
RAAB, Rapid Assessment of Avoidable Blindness.

methods to obtain and record the data for reference) were provided to each team. In cases where a kappa of 0.7 was not achieved for the interobserver variability test, teams were retrained on problematic areas and the test was repeated until the required standard was achieved.

Data management

Data were collected using the RAAB7 app on Android mobile devices and synced to the RAAB Amazon Web Services server (located in Mumbai) when devices were connected to the internet. The survey coordinator and principal investigator reviewed data uploads daily and resolved any discrepancies with the examination teams.

Analysis

Standardised, automated RAAB7 analysis provided crude and age-weighted and sex-weighted prevalence estimates and sample proportions.[13] Additionally, Fisher's exact test was used to examine if the difference in retinopathy rates across gender and age-based subsamples was statistically significant or not. A p<0.05 was considered statistically significant. As the population was mostly rural (only a very small proportion of semiurban), a comparison of urban and rural participants was not carried out. As the sample size was not calculated to make subgroup comparison, only the differences found to be significant were reported. Multivariable logistic regression was used to study the effect of various risk factors on DR status in the population.

Patient or public involvement

As the study was conducted using a standardised RAAB protocol, it was not possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

The survey enrolled 4095 people aged 50 years or older, of whom 3867 were examined (response rate was 94.4%). Among these, 3803 (92.9%) were assessed for diabetes (table 1). Seven per cent (95% CI 5.9 to 8.0%) of participants assessed (265/3803) were found to be having diabetes by self-reported status or random blood glucose testing. All people with diabetes in our study had type-2 diabetes. Of these, half were people with previously diagnosed diabetes (49.8%), and half were people with suspected diabetes (50.2%), based on the result of the survey random blood glucose test. Of 265 people detected with diabetes, 224 (84.5%) consented to a dilated fundus examination.

The highest proportion of people with diabetes was found in the age group of 70–79. However, the difference in prevalence of diabetes between gender and age groups (table 2) was not found to be statistically significant.

DR examination status among people previously diagnosed with diabetes

Among people previously diagnosed with diabetes, 84.8% had never had retina screening. A higher proportion of

Table 2 Distribution of people with diabetes by age and gender (original)

Diabetes mellitus status by age group	Women n (%)	Men n (%)	Total n (%) (95% CI)	P value
50–59	69 (6.6)	44 (5.4)	113 (6.1) (4.7 to 7.5)	0.667
60–69	66 (9.4)	40 (6.0)	106 (7.7) (6.3 to 9.2)	
70–79	20 (9.2)	19 (8.2)	39 (8.7%) (5.6 to 11.8)	
80+	4 (6.5)	3 (5.1)	7 (5.8) (1.8 to 9.8)	
Total with diabetes	159 (7.3)	106 (5.9)	265 (7.0) (5.9 to 8.0)	
Total examined for diabetic status	2026	1777	3803	

Table 3 Time since last eye examination for DR among people with previously diagnosed diabetes by gender (original)

Last examination for DR among people with previously diagnosed diabetes	Women	Men	Total	P value
	n (%)	n (%)	n (%)	
None	74 (90.2)	38 (76.0)	112 (84.8)	0.001
Within a year	6 (7.3)	5 (10.0)	11 (8.3)	
Between 1 and 2 years	1 (1.2)	0 (0.0)	1 (0.8)	
More than 2 years	0 (0)	7 (14.0)	7 (5.3)	
Total responses/people with previously diagnosed diabetes	81/82 (98.8)	50/50 (100.0)	131/132 (99.2)	

DR, diabetic retinopathy.

women as compared with men had either never had retina screening or had screening more than 1 years ago (91.4% in women vs 90.0% in men). Of these, 90.2% women and 76.0% men had never had retinal screening. This difference in distribution among the genders was statistically significant (p=0.001) (table 3). 12 persons with previously diagnosed diabetes (9.1%) had undergone retina screening in the last 2 years.

DR severity

Out of the 224 people with diabetes who consented to undergo a dilated examination, 51 (22.8%, 95% CI 18.2% to 27.3%), had any DR or maculopathy, 13 (5.8%) had any sight-threatening DR (ie, severe non-proliferative DR, proliferative DR or clinically significant macular oedema). 16 (7.1%) had referable DR and 13 (5.8%) had referable maculopathy. Only 2/13 participants (15.4%) with Sight threatening diabetic retinopathy (STDR) had laser photocoagulation scars and none had a history of any intravitreal injection. Distribution of severity of DR among men and women is shown in table 4. Proportions of men with sight-threatening DR, referable DR and referable maculopathy were found to be higher than women.

VI among people with diabetes and non-people with diabetes

Among the entire diabetic sample, 19.3% had moderate (presenting VA of less than 6/18 but more than or equal to 6/60 in the better eye) or severe VI (presenting VA of less than 6/60 but more than or equal to 3/60 in the better eye) and 1.5% had blindness (presenting VA of less than 3/60 in the better eye) (table 5). The difference in VI status among people with diabetes and non-people with diabetes was not found to be statistically significant. Among people with diabetes who had severe VI, 60% (3 persons) had cataract. Among those with moderate VI, 43% (20 people) had uncorrected refractive error and among those with mild VI (presenting VA less than 6/12 but equal to more than 6/18 in the better eye), 76% (20 people) exhibited uncorrected refractive error and 11% (3 persons) exhibited cataracts. DR as a cause of VI was seen in 3 (11%) persons with mild VI and 2 (4.3%) persons with moderate VI.

Table 4 Severity of DR and maculopathy among men and women (original)

DR status	Women (%)	Men (%)	Total (%)
Any DR or maculopathy	29 (22.1)	22 (23.7)	51 (22.8)
Any sight-threatening DR	4 (3.1)	9 (9.7)	13 (5.8)
Any laser treatment	1 (0.8)	1 (1.1)	2 (0.9)
Referable DR	6 (4.6)	10 (10.7)	16 (7.1)
Referable maculopathy	4 (3.05)	9 (9.7)	13 (5.8)
Total examined for DR	131	93	224

DR, diabetic retinopathy.

Mode of treatment among the sample population

Among people with previously diagnosed diabetes, 101 (78.3%) were under treatment with oral hypoglycaemic tablets. Only two (1.5%) were using insulin. 26 (20.1%) were using other methods, diet or nothing to control their glucose levels. Three people with diabetes did not report their treatment modality.

Relation of control of diabetes with different modes of treatment

71% of the people on treatment with oral hypoglycaemic tablets were found to have high blood glucoses as compared with 83% on diet and 100% on no treatment or alternative treatment. Among the 26 people who reported to be on non-allopathic treatment (10) or no treatment (16), only 1 (3.8%) was found to be having controlled blood glucose as compared with 30 out of 103 (29.1%) of those on allopathic treatment (table 6). This was found to be statistically significant (p=0.005). Overall 98 out of 129 (76.0%) people with previously diagnosed diabetes who underwent blood glucose were found to have uncontrolled blood glucose.

Out of the 265 people with diabetes in the survey, 2 persons with previously diagnosed diabetes refused to undergo blood test, 41 refused dilated fundus examination and in 5 patients retina could not be visualised after dilation. Thus, in the remaining 217, the relation between diabetic control and DR could be studied. 23.2% of those who had high blood glucose and 26.1% of those with controlled blood glucose had any DR (table 7).

Table 5 Vision impairment prevalence among people with diabetes and non-people with diabetes (original)

Level of vision impairment (VI)	People with diabetes N (%)	95% CI	Non-people with diabetes N (%)	95% CI
Blind	4 (1.5)	0.1 to 2.9	63 (1.8)	1.3 to 2.3
Severe VI	5 (1.9)	0.3 to 3.5	118 (3.3)	2.7 to 3.9
Moderate VI	46 (17.4)	12.9 to 21.8	554 (15.7)	14.3 to 17.0
Mild VI	26 (9.8)	6.3 to 13.3	308 (8.7)	7.6 to 9.8
No VI	184 (69.4)	63.9 to 75.0	2495 (70.5)	69.0 to 72.0
Diabetes status assessed	265		3538	

Relation of duration of diabetes and control of blood glucose with DR

Nine out of the 21 people with previously diagnosed diabetes for 10 or more years (42.9%) had DR as compared with 28 (31.1%) of those with diabetes of less than 10-year duration (table 7).

Using multivariable logistic regression (table 8), in our survey, the risk odds of developing DR were found to be higher in people with diabetes with blood glucose more than or equal to 200 mg/dL compared with those with lower random blood glucose level (OR 1.6), and in people with diabetes with diabetes of 10 years or longer duration compared with lesser duration and those above 60 years of age (OR 1.8). However, these were not found to be statistically significant.

Extrapolating from our sample, an estimated 28 000 people over 50 years of age are people with diabetes in our catchment with more than 14 000 not knowing their diabetic status. More than 24 000 are in the need of first time DR screening and more than 1400 need treatment for STDR.

DISCUSSION

Our study found the sample prevalence of known or suspected diabetes to be 7.0% (95% CI 5.9% to 8.0%), of which half were previously not aware of their diabetes. Among people with diabetes, the prevalence of DR was 22.8%. More than 85% of people with previously diagnosed diabetes had never had retina screening. One of the strengths of our study was a very high response rate both for RAAB (94%) and the DR module of RAAB (93%).

The sample prevalence of diabetes in our study was found to be lower than the national estimate of 11.8% (95% CI 11.6% to 12.1%) found in a series of RAAB surveys with comparable definition of diabetes.[14] However, in the national RAAB survey, the prevalence was lower in rural areas compared with urban areas (10.5%, 95% CI 10.2% to 10.8% vs 18.3%, 95% CI 17.5% to 19.0%, respectively).[14] Other population-based surveys have demonstrated a similar urban–rural divide—a 2014 study from rural south India also reported similar lower diabetes prevalence of 10.4% (95% CI 10.39% to 10.42 %)[15] and a study from rural and tribal Gujrat found this prevalence to be 4.9% (95% CI 4.2% to 5.5%).[16] while an RAAB-DR in an urban population in Pune found a diabetes prevalence of 21.9% (95% CI 20.1% to 23.7%).[17] As the population of our catchment (and the study sample) was rural, the lower prevalence in our study is in keeping with trends in previous studies.

An important finding was that almost 50% of the people with diabetes in our survey were previously unaware of their diabetic status. This figure is higher than other population-based studies from the country. The national RAAB survey found about one-third of people with diabetes as newly diagnosed.[14] Studies from rural south India and urban western India, estimate the proportion of new people with diabetes as 21% and 18%, respectively, in their regions.[15 17] This difference brings out the lack of awareness regarding diabetes in our region. Low awareness of the disease has been previously reported in rural areas in an earlier Indian study.[18] A study in Papua New Guinea also showed that lack of knowledge about DR was an important barrier.[19] In fact, higher literacy levels have been shown to be associated with good knowledge and

Table 6 Diabetes control among people with previously diagnosed diabetes related to treatment

Type of treatment reported among people with previously diagnosed diabetes	People with previously diagnosed diabetes with controlled blood glucose n (%)	People with previously diagnosed diabetes with uncontrolled blood glucose n (%)	Total
Allopathic treatment	30 (23.1)	73 (70.9)	103
Other treatment or no treatment at all	1 (3.8)	25 (96.2)	26
Total	31 (24.0)	98 (76.0)	129

Table 7 Retinopathy status related to duration of diabetes in people with previously diagnosed diabetes and control of blood glucose among all people with diabetes

Retinopathy status			
Duration of diabetes among people with previously diagnosed diabetes	Retinopathy present	No retinopathy	Total
10 years or more (%)	9 (42.9)	12 (57.1)	21 (100.0)
Less than 10 years, (%)	28 (31.1)	62 (68.9)	90 (100.0)
Total responses	37	74	111
Control of blood glucose among all people with diabetes			
Less than 200 mg/dL	6 (26.1)	17 (73.9)	23 (100.0)
More than or equal to 200 mg/dL	45 (23.2)	149 (76.8)	194 (100.0)
Total responses	51	166	217

awareness of diabetes in previous studies from south and north India.[20 21] The average literacy rate in both Shahjahanpur and Lakhimpur Kheri districts is only 60%,[11] and the low awareness of diabetes among the population may be attributed to the same. Most of the people with previously diagnosed diabetes (78.3%) in our study were under treatment with oral hypoglycaemic medications and most (76%) had uncontrolled blood glucose. One of the limitations of the study was that in this rapid survey, names of the actual medication or the adherence to treatment could not be captured. Almost all (25 out of 26, 96%) people with previously diagnosed diabetes on alternative therapy, dietary control only or no treatment were found to be having significantly higher proportion of people with uncontrolled blood glucose. High proportion of people with diabetes not knowing their status and a high proportion of people with previously diagnosed diabetes having poorly controlled glucose brings out the need for better awareness and primary care services in the region.

This study found the prevalence of any DR was 22.8% (95% CI 18.2% to 27.3%). This is higher than the prevalence reported in the national RAAB (16.9%, 95% CI 11.6% to 12.1%), and higher than that reported by the national RAAB for the two districts in UP, Banda and Ambedkar Nagar (6.6% and 9.2%, respectively).[14] Other north Indian districts in the national RAAB reported higher prevalence of DR than the districts in UP, ranging from 14.2% to 21.1%.[14] A study from rural Bihar showed the prevalence of any DR at 15%,[22] while one from urban Pune reported prevalence of 14.3%.[17] A 2022 systematic review and meta-analysis from India showed prevalence of DR was 17.4% in urban and 14.0% in rural populations. The study attributes the narrow difference to 'rapid urbanisation and uneven development in different parts of India in the last two decades'.[23] In our survey, around half of the people with diabetes were not aware of their status and around 76% of people with previously diagnosed diabetes had poor control. As the prevalence of DR is related to the control of blood glucose, this could have led to higher prevalence of DR in our study. This could still be an underestimate as RAAB-DR is a rapid examination protocol and does not include fundus photography. As there is no particular trend in DR prevalence that can be pin-pointed across India, RAAB-DR surveys like ours add immense value in planning services for unique catchments.

The WHO has included retina screening coverage for people with diabetes as a core indicator for eye health.[24] RAAB-DR studies like ours can be an important alternative to facility-based sources for this data. In our study, 84.8% of the people with previously diagnosed diabetes had never had an eye examination for DR. This proportion is in keeping with results from rural South India,[15] rural Bihar[22] and urban Pune,[17] as well the national RAAB14,[14] where the majority of the people with previously diagnosed diabetes of the population had not undergone any previous eye examinations for DR. The proportion of

Table 8 Results of logistic regression with presence of diabetic retinopathy as an outcome

Covariates	OR	95% CI Lower limit	95% CI Upper limit	P value
Intercept	0.54	0.11	2.32	0.4
Random blood glucose ≥200 mg/dl (ref: random blood glucose <200 mg/dL)	1.43	0.51	4.42	0.5
Duration of diabetes ≥10 years (Ref: <10 years)	1.81	0.61	5.28	0.2
Allopathic treatment for diabetes	0.52	0.18	1.52	0.2
Age above 60 years (Ref: Age below 60 years)	1.65	0.68	4.02	0.2
Age above 70 years (Ref: Age below 70 years)	0.89	0.10	6.35	0.9
Female (Ref: Male)	0.81	0.35	1.90	0.6

women who had undergone eye examination for DR in our survey was significantly lower than men and this was similar to the results of the national RAAB survey.[14] The high prevalence of DR combined with poor coverage of screening in our survey highlights the need for improving DR-related services in the region.

At present, models from the country primarily report DR screening efforts aligning with the existing public healthcare system[25–27]; innovation and testing of artificial intelligence-based screening techniques using fundus cameras[28 29]; implementation of telescreening initiatives and their cost evaluations.[30] The success of these models in bridging the patient-side barriers to DR screening provides the evidence needed for systematic DR screening to be amalgamated in the existing public health system. A study on barriers to screening among young people with diabetes belonging to ethnic minorities in Baltimore, USA, showed difficulty to find time for additional appointment and additional cost as important barriers,[31] thus, highlighting the importance of integration. The role of VCs in reaching the community as well as forming the fulcrum of the service provision pyramid has been detailed previously.[32] Evidence also exists to support the role VCs play in furthering gender equity in access to eye care in rural areas.[33] Thus, going forward, there is a need to expand the role of VCs to include regular awareness creation and screening for diabetes and DR, using these latest techniques and innovations. This is also specifically applicable in the study region as the service provider organisation responsible for this RAAB, has existing VCs in the region. We feel integration of screening within existing public health systems and existing VC networks can limit the additional cost required but cost-effectiveness evaluations are recommended.

The prevalence of STDR was found to be 5.8% which was higher than the national average of 3.6%.[14] Only 2 of the 13 cases (15%) had received laser treatment. This highlights the need for early detection by screening and improving the treatment coverage in the region. Provision of retinal lasers and training general ophthalmologists for treatment at secondary eye care has also been recommended as one of the interventions in a health policy paper for south Asia.[34]

Although we found that people with diabetes with better control had slightly higher prevalence of DR (26.1% vs 23.2% in people with diabetes with blood glucose more than or equal to 200 mg/dL), this could be due to certain confounding factors as in multivariate analysis people with diabetes with uncontrolled blood glucose and diabetes of 10 years or more were found to be at higher risk of having DR. This is similar to the findings of the national RAAB survey.[14] One of the limitations of the RAAB sample size calculations is that the sample size is not calculated to perform subgroup analysis or comparisons. Thus, some of these associations and comparisons may not have been found to be statistically significant. Also, as the study was conducted as per the protocol of the 'rapid' survey,[7] other systemic factors like blood pressure and body mass index could not be assessed or correlated.

The prevalence of blindness and VI in people with diabetes and people without diabetes was found to be similar in the study population. These results differ from results published from rural Bihar, where the prevalence of severe VI was found significantly higher in people without diabetes[22] but echo the trends published previously from national RAAB survey[14] where the prevalence of severe VI was found to be similar in people in both groups. However, this might change with the ageing of population and thus increased duration of undetected diabetes.

In conclusion, traditionally RAAB is carried out in a geographical region delimited by geo-political boundaries. We believe our study is the first RAAB-DR carried out in a district customised according to the catchment of a high-volume surgical centre with an expanding primary eye care centre network. This model may be replicated by other providers where the catchments do not conform to standard geo-political boundaries. The proportion of people with diabetes not aware of their status, the prevalence of DR and proportion of people with previously diagnosed diabetes not having undergone retina screening were found to be higher than in the national RAAB survey estimates. Thus, in addition to providing baseline population-level data, the results will help us to plan services for an estimated 28 000 people with diabetes in this catchment. Multisectoral involvement and leveraging primary eye care centres are recommended to improve services.

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