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Measuring the prevalence of uncorrected refractive errors and refractive error coverage among the young working age population in Kasganj district, Uttar Pradesh, India, using rapid assessment of refractive error methodology

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Background: There is limited evidence on prevalence of uncorrected refractive errors (URE) in younger population. This study assessed prevalence of URE, spectacle coverage and barriers to RE services among individuals aged 15–49 y in Kasganj district, North India.

Methods: This was a cross-sectional population-based survey, where uncorrected, corrected and best-corrected visual acuity and lens status were assessed. Updated WHO definitions were used for VI, URE, refractive error coverage (REC) and effective REC (eREC).

Results: Of 3167 people examined, VI was identified in 73 cases (2.3%). Age-sex adjusted prevalence of URE was 3.2% (2.5–4.1%) which increased significantly above 40 years (8.8%). Females were more affected than males (3.7% vs 2.8%). Presbyopia affected 42.7% of people aged >35yrs, with higher rates among females (44.6% vs males 40.9%). REC and eREC for distance were 32.5% and 27.5%, respectively, with notable gender disparities. REC for presbyopia was 14.7% (males: 19.7%; females: 9.6%). Distance to services (40%), social constraints (28%) and 'low perceived need' (22%) were identified as the key barriers to accessing RE services.

Conclusions: URE is a major public health challenge amongst working population in rural North India. Targeted interventions to increase coverage are needed to meet WHO's 2030 target.

Keywords: effective coverage, prevalence, refractive error, refractive error coverage, visual impairment.

Introduction

Of the 2.2 billion individuals worldwide experiencing some form of visual impairment (VI), about one-half are affected by conditions that could have been prevented or treated.[1] A major contributor to this burden is uncorrected refractive error (URE), which affects individuals across all age groups, and has long been recognized as a priority eye disease.[2–4] Most UREs can be easily corrected at the primary care level with spectacles.[5] However, despite the availability of this cost-effective treatment strategy, it continues to be a major public health challenge, particularly in low- and middle-income countries. This has a substantial impact on the quality of life and economic development in these countries.[6,7] Recognizing this crisis, the 74th World Health Assembly in 2021 established the first-ever global target for RE, a 40-percentage point increase in the effective coverage of RE (eRCE) by 2030 (defined as the proportion of individuals with corrected RE achieving good vision among all those needing correction).[8,9] This also highlights the importance of collecting URE data through periodic regional surveys as a mechanism to understand the burden of VI and to monitor countries' progress towards the target.

Most VI surveys focus on older people (aged ≥40 y) because the prevalence of blindness is expected to be high in this age group and they also form the most immediate targets for interventions focused on avoidable blindness.[5,10,11] In India, the prevalence of VI in individuals aged >50 y is 26.6%, of which 41.5% is due to URE.[10]

There are very limited data about URE in younger age groups. A systematic review estimated the prevalence of RE (>0.5 diopters) among people aged >30 y at 53.1%, whereas the prevalence of URE was 10.2%.[12] Rapid Assessment of Refractive Error (RARE) survey methodology was introduced by Marmamula et al. to estimate the prevalence of RE causing VI among people aged 15–49 y.[11]

Kasganj is a predominantly rural district in Uttar Pradesh (North India) with a total population of 1.44 million, of which almost one-half (48%) is aged 15–49 y.[13] An unpublished Rapid Assessment of Avoidable Blindness conducted by Sightsavers India in 2022 revealed a blindness prevalence of 3.5% (95% CI 2.8 to 4.3%) among those aged ≥50 y in this district (Sightsavers India. Rapid Assessment of Avoidable Blindness (RAAB) Report, Kasganj: unpublished report. Sightsavers India; 2021). This was significantly higher than the national average of 1.99%, as per the national survey conducted in 2019.[10] The study also reported that, while unoperated cataract was the major cause of blindness and severe VI, almost one-third of all VI was due to URE. It was postulated that a similar trend may exist in the younger population (aged <50 y), who were as yet not accessing the eyecare services for early detection and treatment of their eye diseases and will eventually contribute to the future burden of VI and blindness.

The current study was thus aimed at addressing this knowledge gap and measuring the prevalence of VI and URE (both distance and near vision) and their association with key sociodemographic factors among individuals aged 15–49 y in Kasganj district, Uttar Pradesh. The study also explored barriers to accessing RE services in this age group.

Methods

The survey was conducted using the RARE methodology, which has been well described elsewhere and used in various locations within India[11] and other countries.[14–17] It is a descriptive cross-sectional population-based survey that allows rapid collection of data about the magnitude and distribution of URE among individuals aged 15–49 y with relatively low resources.

Sample size and sampling procedure

The minimum sample size was calculated using an estimated prevalence of URE of 3%, 90% confidence interval, 20% relative precision and design effect of 1.5 to adjust for the cluster sampling.[12] An additional factor of 10% was included to compensate for potential non-responders. These led to a sample size of 3250 individuals, translating into 65 clusters of 50 individuals each.

A multistage cluster random sampling methodology was employed, where initially the primary sampling units (65 villages) were identified randomly using probability proportionate to size. Within each village, a compact segment sampling approach was employed to enroll 50 consecutive eligible individuals (i.e. aged 15–49 y and being a permanent resident of the cluster).

Eye examination protocol and definitions

Four survey teams, each comprising one senior and one junior optometrist and a health worker, were deployed to carry out the survey. They were trained to follow a standardized protocol for the assessment of eye health status for the eligible participants during 3 d of training. An interobserver variance assessment was conducted on the final day of training to ensure a high level of agreement between the teams (kappa>0.7), thus ensuring consistency and quality of data.

In the field, the teams visited preassigned clusters and started house-to-house surveys. After confirming the eligibility of the respondent and receiving consent from them, the optometrist assessed the distance vision of both eyes using a Snellen chart with tumbling 'E' optotypes at 6 m. If the individual was using distance vision glasses, both unaided and aided distance vision was assessed. Participants with presenting vision (PVA) <6/12 in either eye were reassessed using a pinhole for that eye to estimate the best corrected vision (BVA). Near vision was assessed binocularly using the N notation chart at a fixed distance of 40 cm.

Torchlight examination was performed for all individuals to assess the anterior segment of the eyes. Lens status was assessed by using torchlight and distant direct ophthalmoscopy in a shaded environment without pupillary dilatation.

Apart from collecting demographic details such as age, education and occupation, information about current and past use of spectacles was also collected from respondents using a structured questionnaire. Individuals who had URE but were not using any spectacles were also asked about key barriers to the uptake of RE services.

Survey definitions

VI was defined as PVA<6/12 in the better eye. When this improved to ≥6/12 with pinhole, this was labeled as being due to URE. Presbyopia was defined as an inability to read the N8 line at a distance of 40 cm binocularly, for participants aged >35 y who had distance visual acuity of ≥6/12.[12]

For calculating refractive error coverage (REC), individuals with RE were classified into three categories. People with unaided vision <6/12 that improved to 6/12 with pinhole and not using any spectacles constituted the 'Unmet need'. Those with unaided vision <6/12 but that improved to ≥6/12 with current spectacles were classified as 'Met need'. By contrast, individuals whose aided vision with current spectacles was <6/12 but improved to 6/12 with pinhole were regarded as 'Under-met need'. The sum of all three was considered as 'total need'. From these, the coverage indicators were estimated using the approach proposed by McCormick et al.[8]

Data collection

The survey was conducted using a mobile application designed in the CommCare platform (Dimagi Inc, https://dimagi.com/commcare). The data were later compiled as a MS Excel file for analysis using STATA statistical software (Release 12; StataCorp LLC, College Station, TX, USA).

The crude prevalence of URE and VI among participants aged 15–49 y was estimated and expressed as proportions with 95%

Table 1. Demographic distribution among participants in the sample

	Demography		
Age group (y)	Males n (%)	Females n (%)	Total n (%)
15–29	820 (50.9)	824 (52.9)	1644 (51.9)
30–39	365 (22.7)	352 (22.6)	717 (22.6)
40–49	425 (26.4)	381 (24.5)	806 (25.4)
Education level			
No education	338 (20.9)	659 (42.3)	997 (31.5)
Primary school	211 (13.1)	202 (13.0)	413 (13.0)
High school	503 (31.2)	345 (22.2)	848 (26.8)
Intermediate and above	558 (34.7)	351 (22.5)	909 (28.7)
Occupation			
Student	335 (20.8)	272 (17.5)	607 (19.2)
Unskilled laborer	928 (57.6)	18 (1.2)	946 (29.9)
Skilled laborer/small business owner	302 (18.8)	31 (2.0)	333 (10.5)
Unemployed/ homemaker	45 (2.8)	1236 (79.4)	1281 (40.4)

CIs. Prevalence was then age- and gender-standardized to the study population structure to minimize potential confounding by demographic variations.

Multivariate logistic regression analysis was performed to test the association of URE and VI (outcome variables) with age, gender, educational attainment and occupation (predictor variables). Results are presented as ORs with corresponding 95% CIs. To account for the cluster random sampling design, the survey analysis commands (*svy* suite in STATA) were used. $p<0.05$ was considered statistically significant for all analyses.

Results

Participant characteristics

The survey enrolled 3250 eligible participants, of whom 3167 (97.5%) were available and agreed to participate. The response rate was significantly higher among women (98.4%) compared with men 96.5% ($p=0.002$). The mean age of participants in the sample was 29.9 (SD 10.33) y; and 50.8% were males. There was no significant difference in mean age between responders and non-responders.

Nearly one-third (31.4%) of the respondents had no formal education; 13.0% had completed primary school; 26.8% had reached high school and 28.7% achieved intermediate or higher-level education. Most respondents were either housewives or unemployed men (40.4%). Other occupational groups included unskilled laborers (29.9%), skilled laborers or small business owners (10.5%), while students represented 19.2% of participants (Table 1).

Visual impairment

Among 3167 participants, 73 (2.3%) had presenting vision <6/12 in the better eye. Age- and gender-adjusted prevalence of VI was 1.8% (95% CI 1.3 to 2.5%). Women had a higher prevalence compared with men (1.9% vs 1.6%), but the difference was not statistically significant ($p=0.326$). The prevalence was significantly higher in the 40–49-y age group (6.4%, 95% CI 4.8 to 8.4%; $p<0.000$).

Upon multivariate analysis, age >40 y had a strong association with VI (OR 16.2, 95% CI 6.6 to 39.6; $p<0.000$). Having a formal education (primary and above) was also associated with lower odds of experiencing VI compared with not having a formal education (OR 0.7, 95% CI 0.4 to 1.2; $p=0.0002$). Some occupational differences also emerged, with unemployed men/housewives having the highest odds of experiencing VI (OR 2.4, 95% CI 1.0 to 5.8; $p=0.05$), but these lacked statistical significance in the overall model (Table 2).

Overall, URE was the most common cause of VI (57 cases, 78.1%) followed by unoperated cataract (12 cases, 16.4%). Corneal opacity and other posterior segment pathologies were also responsible for VI in a few cases (approximately 3% each).

Refractive error

The study identified 121 individuals with URE for distance, of which males accounted for 46.3% (56) and 53.7% (65) were females. Unilateral URE was more common in females (62.0%, 31 cases), while bilateral URE was more common in males (52.1%). Overall, bilateral cases predominated (58.7%, 71) over unilateral cases (41.3%, 50) (Table 3).

Age- and gender-adjusted prevalence of URE was 3.2% (95% CI 2.5 to 4.1%). There was a significant age-related trend, with prevalence increasing from 1.7% (95% CI 1.1 to 2.6%) in 15–29-y-olds to 8.8% (95% CI 6.7 to 11.4%) in 40–49-y-olds ($p<0.000$). Females had a higher URE prevalence than males, but this difference was not statistically significant (females 3.7% vs males 2.8%; $p=0.097$). It was observed that individuals with 'no formal education' had a higher prevalence of URE (4.5%, 95% CI 3.1 to

Table 2. Prevalence and risk factors of visual impairment among participants (N=3167)

	Visual impairment			Multivariate analysis		
Age group (y)	%	95% CI	p*	OR	95% CI	p
15–29	0.6	(0.3, 1.2)		Reference		
30–39	0.9	(0.4, 2.3)		2.3	(0.8, 6.6)	0.10
40–49	6.4	(4.8, 8.4)	<0.000	16.2	(6.6, 39.6)	0.00
Gender						
Male	1.6	(1.1, 2.4)		Reference		
Female	2.0	(1.3, 2.9)	0.326	1.2	(0.8, 1.9)	0.32
Education level						
No education	3.4	(2.2, 5.0)	0.0002	Reference		
Primary and above	1.2	(0.7, 1.8)		0.7	(0.4, 1.2)	0.16
Occupation						
Student	1.0	(0.5, 2.2)		Reference		
Unskilled laborer	1.6	(1.0, 2.5)		1.7	(0.7, 3.9)	0.22
Skilled laborer/small business owner	1.8	(0.8, 3.9)		1.8	(0.6, 5.6)	0.31
Unemployed/homemaker	2.4	(1.5, 3.7)	0.125	2.4	(1.0, 5.8)	0.05

*χ^2 test.

Table 3. Distribution of unilateral and bilateral uncorrected refractive error in the sample

	Unilateral		Bilateral		Total	
Gender	n	%	n	%	n	%
Male	19	33.9	37	66.1	56	46.3
Female	31	47.7	34	52.3	65	53.7
Total	50 (41.3%)		71 (58.7%)		121	

6.4%) compared with those with 'primary school and above' education (2.7%, 95% CI 1.9 to 3.7%; p=0.25). Multivariate analysis revealed that people aged >40 y in the sample had almost sevenfold higher odds of experiencing URE compared with those aged 15–29 y (OR=6.6, 95% CI 3.5 to 12.2; p<0.000). The association of URE with other explanatory parameters such as gender, education and occupation was not found to be statistically significant (Table 4).

Refractive error coverage

At presentation, only 133 individuals (4.2%) were using spectacles. Of these, 68 (51.1%) were males and 65 (48.9%) were females. Most of these wore single-vision glasses (near 51.9%, distance 36%). Only 12% were using bifocal glasses. There were 22 cases using spectacles for distance and that had corrected vision >6/12 (met need). Fifty-four cases had BVA=6/12, but they did not have spectacles (unmet need). Four cases were unable to achieve an optimal visual outcome (≥6/12) with glasses (under-met need).

Thus, using the formula proposed by McCormick et al., REC was calculated as 32.5% and the effective REC (eREC) was 27.5%. Both were higher for males compared with females (REC 41.9% males vs 21.6% females; eREC 37.2% males vs 16.2% females) (Table 5).

Presbyopia

Of the 1088 people aged>35 y, 464 were unable to read N8 at presentation (42.7%, 95% CI 39.7 to 45.5%). The prevalence of presbyopia among females (44.6%, 95% CI 40.3 to 48.9%) was higher than among males (40.9%, 95% CI 36.9 to 44.9%), but this was not statistically significant.

Only 68 (14.7%) of these individuals had access to near vision spectacles (REC- Near) and the coverage was considerably lower for women (9.6%) compared with men (19.7%) (Table 6).

Barriers to the uptake of refractive error services

People with an URE but who were not using eyeglasses were asked their reasons for not accessing RE services. The most prominent reason (40%) reported was that the eyecare services were 'too far' from where their home was. While females reported 'social reasons' as the next most common barrier (33.3%), lack of 'felt need' for spectacles was cited as the second most common (25%) barrier among men. Lack of 'affordability' was noted as a limitation only by a few respondents (10%).

Discussion

To the best of our knowledge, this is the first population-based study in Uttar Pradesh (North India) utilizing the RARE methodology to estimate the burden of URE and spectacle coverage

Table 4. Prevalence and risk factors of refractive errors among participants (N=3167)

	URE			Multivariate analysis		
Age group (y)	%	95% CI	p*	OR	95% CI	p
15–29	1.7	(1.1, 2.6)		Reference		
30–39	2.5	(1.5, 4.1)		1.7	(0.8, 3.5)	0.14
40–49	8.8	(6.7, 11.4)	<0.000	6.6	(3.5, 12.2)	<0.000
Gender						
Male	2.8	(2.0, 3.8)		Reference		
Female	3.7	(2.7, 5.0)	0.097	1.8	(0.7, 4.5)	0.18
Education level						
No education	4.5	(3.1, 6.4)	0.025	Reference		
Primary and above	2.7	(1.9, 3.7)		1.0	(0.6, 1.6)	0.98
Occupation						
Student	2.1	(1,2, 3.5)		Reference		
Unskilled laborer	3.2	(2.2, 4.5)		0.7	(0.3, 2.0)	0.59
Skilled laborer/small business owner	4.0	(2.2, 6.9)	0.184	1.0	(0.4, 2.4)	0.93
Unemployed/homemaker	3.7	(2.6, 5.2)		0.6	(0.2, 1.3)	0.18

URE: uncorrected refractive error.
*χ^2 test.

Table 5. REC and eREC - distance

URE	Met need a	Under-met need b	Unmet need c	Total need (a+b+c)	REC* (%) (a+b)/(a+b+c)	eREC# (%) a/(a+b+c)
Male	16	2	25	43	41.9	37.2
Female	6	2	29	37	21.6	16.2
Total	22	4	54	80	32.5	27.5

eREC: effective refractive error coverage; REC: refractive error coverage; URE: uncorrected refractive error.
*REC=(met need+under-met need)/(total need)x100.
#eREC=((met need)/(total need))x100.

Table 6. REC-near

Presbyopia	Met need	Unmet need	Total need	REC (%)
Male	46	188	234	19.7
Female	22	208	230	9.6
Total	68	396	464	14.7

REC: refractive error coverage.

among individuals aged 15–49 y. The high response rate (97.5%), achieved through localized strategies and community engagement, enhances the representativeness and validity of our findings.

Our study found that the prevalence of VI among the 15–49-y age group was 1.8% (95% CI 1.3 to 2.5%), with females experiencing a higher burden compared with males (1.9% vs 1.6%). Most of this was due to URE (78%), with some contribution due to unoperated cataract (16.4%). These findings are corroborated by a recent study in Jajjhar district, Haryana (North India), where the authors used a Rapid Assessment of Visual Impairment methodology and estimated bilateral VI in those aged 15–49 y at 1.85%, with most (83.5%) due to URE. Both the current study and Subburaman et al. also found age >40 y and a lack of formal education as significant associations with VI.[18]

The age- and gender-adjusted prevalence of URE in our study was estimated at 3.2% (95% CI 2.5 to 4.1%), which increased significantly with age, reaching nearly 9% in the 40–49-y age group compared with 1.7% in younger individuals (aged 15–29 y). These values are higher than those reported in South India, where the prevalence of URE causing VI was 2.7% (95% CI 2.1 to 3.2%). This trend is consistent with difference in the magnitude of blindness and VI between North and South India, which could be related to the lower level of education and overall poorer coverage of health services in North India.[10,12]

Presbyopia, often neglected in younger population assessments, was identified in 42.7% of individuals aged >35 y, with a higher prevalence among women (44.6%). Only 14.7% of these individuals had access to near vision spectacles, with even lower coverage in women (9.6%). This significant gender gap underscores the need to explore social and cultural barriers limiting women's access to eye care, as has been highlighted in previous research.[12]

The REC in our study was 32.5%, with eREC at 27.5%. Compared with other RARE studies conducted in Andhra Pradesh (REC: 29%) and Eritrea (REC: 22.2%),[12,16] our findings suggest a modest improvement, but still insufficient service utilization.

While the estimates in the current study are lower than those reported from Theni district, Tamil Nadu, South India (REC: 35.5%; eREC: 33.4%), this could be due to the enrolment of a wider age group (1–100 y) in that study, where the prevalence of URE was also much higher (12%).[19]

Similar to all previous reports, gender disparity was present in our study as well, with males achieving higher coverage (REC: 41.9%) than women (21.6%). The survey from Theni district also identified rural and less educated groups, particularly women, experiencing consistently lower access to refractive services.[19]

In the current study, 'distance from services' was reported as the most common barrier (40% respondents) to accessing RE services, followed by 'social reasons' (28%) and 'lack of felt need' (22%). Lack of 'affordability' was mentioned only in 10% of cases. These findings contrast with the report from Andhra Pradesh, South India, where 'economic reason' was the key barrier (30.9%) and lack of 'felt need' and poor 'access to services' were 23% and 16.5%, respectively.[19] This could be related to the differences in the sociodemographic and economic context of the two study populations.

The current study's strengths include its robust sampling design, high response rate (>97%) and use of standardized RARE methodology, allowing comparability with other regional and national surveys. Also, due to its simplicity, low cost and feasibility, the RARE methodology seems like an ideal model for large-scale screening in resource-limited settings. It can also be easily repeated to assess the impact of ongoing interventions on the REC and quality.

However, limitations include the reliance on torchlight and pinhole assessments without comprehensive refraction, which may underestimate certain REs. Furthermore, the cross-sectional design precludes inference about temporal trends in URE prevalence.

The current study reinforces the observation that, even among younger working-age populations, URE remains a leading cause of correctable VI. This has implications for productivity, education and quality of life. The relatively higher prevalence and low REC, especially among women and those with no formal education, highlights persistent inequities in access to refractive services. These findings are consistent with national and global reports that call for addressing gender, socioeconomic and geographic barriers to RE correction.[9]

In conclusion, this study underscores the urgent need for targeted interventions to address the burden of URE and low spectacle coverage among the working-age population in rural India. Strengthening optical service delivery, improving health workforce distribution and addressing sociocultural barriers will be crucial in ensuring universal access to refractive care and preventing avoidable vision loss.

Authors' contributions: SB and ABS collaborated on the design of the survey and development of the data collection tool. SB took the lead on the RARE survey, overseeing training and conducting all quantitative analyses. ABS provided support for data collection and contributed to report writing. PNP provided overall guidance for this survey. All authors participated in the creation, review and approval of the final manuscript.

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Ethical approval: The study protocol was approved by Sigma IRB, the institutional review board at Sigma Research and Consulting Private Limited in Delhi, India (IRB# 10015/IRB/23–24). Before initiating the data collection process, written consent was obtained from the respondents or their guardians after explaining the purpose and nature of the survey.

Data availability: The data underlying this article will be shared upon reasonable request to the corresponding author.

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