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Near vision impairment and effective refractive error coverage for near vision in Andhra Pradesh, India – The Akividu Visual Impairment Study (AVIS)

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ABSTRACT

Clinical relevance: Near Vision Impairment (NVI) is common in developing countries. A substantial proportion of NVI can be addressed by providing spectacles. Innovative eye care programmes are needed to address NVI. Population-based epidemiological studies can provide vital data to plan such eye care service delivery models.

Background: To report the prevalence of NVI and effective Refractive Error Coverage (eREC) for near vision in West Godavari and Krishna districts in Andhra Pradesh, south India.

Methods: A population-based cross-sectional study was carried out using a Rapid Assessment of Visual Impairment methodology. Presenting and pinhole distance visual acuity were assessed followed by near vision assessment using a N notation chart at a fixed distance of 40 cm. If the presenting near vision was worse than N8, the best corrected near visual acuity was recorded with age appropriate near vision correction. NVI was defined as presenting near vision worse than N8 among those without distance vision impairment (6/18 or better in the better eye). Effective Refractive Error Coverage for near was calculated as the proportion of individuals with an adequate correction to the total participants, including those with inadequate, adequate, and no correction for near vision.

Results: Data of 2,228 participants aged ≥40 years were analysed. The mean age of these participants was 54.0 ± 10.4 years; 53.8% were women; 44.5% had no formal education. The prevalence of NVI was 27.1% (95% CI: 25.2–29.0%). NVI significantly associated with 70 and above age group (adjusted OR: 1.97; 95% CI: 1.45-3.70). Participants with formal education had lower odds for NVI (adjusted OR: 0.75; 95 % CI: 0.68-0.83). The eREC for near vision was 48.0%.

Conclusion: NVI affects over a quarter of people aged ≥40 years in the West Godavari and Krishna districts of Andhra Pradesh. However, eREC is under 50% and there is scope for improving this by establishing eye care services to achieve universal eye health for all.

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Introduction

Globally, it is estimated that 510 million are affected by near vision impairment (NVI). It is projected that this number will increase to 866 million people by 2050.[1] Over 90% of NVI is reported from developing countries.[2] Most NVI can be corrected by a pair of spectacles. Despite this low-cost interventions, Fricke et al. reported that over 40% of people with NVI either had no spectacles or had inadequate correction.[3]

The prevalence of NVI is higher among people in older age groups with no formal education and those living in low to middle-income countries.[2,4–8] Bastawrous et al. reported that the provision of near-vision glasses might avert 1.2 billion life years of presbyopia and improve productivity gains by US$ 1.05 trillion.[9] A randomised control trial reported a substantial increase in work productivity among Indian tea pickers with near-vision glasses.[10]

The prevalence of NVI is reported in several population based studies in India. The prevalence of NVI ranges from 36% to as high as 64% in some parts of India.[11–15] However, only two studies have reported the prevalence of NVI in the state of Andhra Pradesh.[14,15] The Andhra Pradesh Eye Disease Study (APEDS) conducted during 1996–2000 and a rapid assessment of visual impairment (RAVI) study in 2012 were the major population-based studies conducted in the state of Andhra Pradesh.[12,13] The prevalence of NVI was 55.3% and 34.5% in the APEDS and RAVI studies, respectively.[12,13] There are no recent studies reporting on the prevalence of NVI in this state.

Effective Refractive Error Coverage (eREC) for distance and near vision are important indicators for planning and monitoring of eye care services.[16] Refractive Error Coverage (REC) is similar to Spectacles Coverage reported in several studies.[6,13,15,17,18] More recently, effective REC for distance and near vision is proposed as an indicator to assess progress towards universal health coverage using the integrated people centred eye care approach.[16] In addition to 'met need' (corrected refractive error) and 'unmet need' (uncorrected refractive error), eREC includes an additional element of 'undermet need' which is defined as under corrected or inadequately corrected refractive error for distance or near.

The Global Action Plan recommends periodic epidemiological assessments to gather data on vital indicators such as eREC to assess the temporal trends over time.[19] Recently, the World Health Assembly has endorsed the global target of a 40-point percentage increase in eREC in the member states by year 2030.[20] The global estimate of eREC for near vision was 20.5% among those aged 50 years and older in year 2021.[17] However, the baseline data on this indicator is not available from several regions of the world including India.

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Akividu Visual Impairment Study (AVIS) is conducted in West Godavari and Krishna districts to establish the baseline on various indicators proposed by the World Health Organisation.[21,22] The prevalence of distance visual impairment and eREC for distance vision are reported from AVIS previously.[21,22] In this paper, the prevalence of NVI and eREC for near vision are reported.

Methods

The Akividu Visual Impairment Study (AVIS) protocol was approved by the Institutional Review Board (IRB) of the Hyderabad Eye Research Foundation, L V Prasad Eye Institute. Written informed consent was obtained from all participants before data collection. The study was conducted during February and June 2019 among individuals aged ≥40 years in the Akividu region, which is part of the catchment area of the secondary eye care facility of the L V Prasad Eye Institute established in 2018.[21,22] The Akividu region comprises 16 sub-districts of the West Godavari and Krishna districts in Andhra Pradesh, with an estimated population of 0.5 million.

The sample size estimation for AVIS was based on an anticipated prevalence of distance visual impairment (presenting visual acuity worse than 6/18 in the better eye) of 6%, precision of 20% and 95% confidence intervals with a 20% inflation to account for non-response.[20,21] A design effect of 1.5 was used to account for the cluster size of 50 participants. The minimum sample size required was 2,817 (rounded to 3000) participants. In total, 60 clusters were randomly selected based on probability proportionate to their size from the sampling frame that comprised all the villages in the Akividu region. Fifty participants were included from each cluster. As this study was nested within another larger study on distance visual impairment, the sample size exceeded that required to assess NVI as it is more prevalent than distance visual impairment.

The available participants were examined in their households. If the participant was unavailable for examination, the household of the participant was visited twice before marking them as unavailable for the eye examination. The study protocol and eye examination procedures were described in a previous publications.[21,22] Three teams comprising a vision technician, field investigator, and field worker, collected the data. Field investigators collected the demographic and personal information of the participants. The clinical examination was done by vision technicians (primary eye care personnel).

The vision technician assessed the unaided and aided distance vision, near vision, and examined the anterior and posterior segments of the eye. Near vision was recorded binocularly in ambient daylight using the N-notation vision chart (E-optotypes) at a fixed distance of 40 cm maintained using a string attached to the chart. Precautions were taken to avoid reflection on the chart. The chart had optotypes ranging from N63 to N6 with five optotypes per line. If a participant correctly identified four out of five optotypes in a line, then it is considered as pass and that specific line was documented.

Unaided near vision was assessed first in all cases followed by aided acuity, if the participant reported spectacles for near vision. Aided vision was considered as presenting near visual acuity for participants with spectacles for near vision. Unaided near vision was considered as presenting near vision acuity for participants with no spectacles. If the presenting near vision was worse than N8, the best corrected near vision was recorded using readymade near vision spectacles (plus spherical lenses) with age-appropriate addition power for near vision. The improvement in near vision with these spectacles was considered for defining the unmet need for spectacles for near vision.

Definitions

All participants with presenting distance vision impairment worse than 6/18 in the better eye were excluded from the NVI analysis. Near vision impairment (NVI) was defined as the presenting visual acuity worse than N8 (6/15).[1] NVI was further classified as mild (worse than 6/15 to 6/18; worse than N8 to N10), moderate (worse than 6/18 to 6/60; N12-N32), and profound NVI (worse than 6/60; worse than N32). Met need was defined as unaided near vision worse than N8 that improved to N8 or better with the spectacles of the participant (corrected NVI).

Under-met need was defined as near vision worse than N8 despite using near vision spectacles (under corrected/inadequately corrected NVI); however, could be improved to N8 or better with correction (age-appropriate near vision reading spectacles). Unmet need was defined as unaided near vision worse than N8 that could be improved to N8 or better with age-appropriate near addition correction spectacles (uncorrected NVI).

REC and eREC for near vision were calculated using the formula[16]:

$$\text{REC for near vision (\%)} = ((\text{met need} + \text{under-met need})/(\text{met need} + \text{under-met need} + \text{unmet need})) \times 100.$$

$$\text{eREC (\%)} = (\text{met need}/(\text{met need} + \text{under-met need} + \text{unmet need})) \times 100.$$

To report the quality of near vision correction services, the Relative Quality Gap (RQG) for REC (%) was calculated using the formula:

$$\text{RQG}(\%) = 1 - (\text{eREC}(\%)/\text{REC}(\%)) \times 100.$$

Data management and analysis

The data were collected using paper forms, and entered into a Microsoft Access database. The data analysis was carried out using Stata statistical software version 14. The age and gender adjusted prevalence of NVI, along with 95% confidence intervals (95% CIs) are reported. A chi-square test was used to compare the prevalence of NVI between the different demographic variables. The association between NVI and demographic variables was tested using multiple logistic regression analysis. The odds ratio (OR) and 95% CIs are reported. The Hosmer–Lemeshow goodness-of-fit test was used to test the fit of the regression model. Statistical significance was set at a p-value of <0.05; however, the exact p-values are reported.

Results

A total of 3,000 participants aged ≥40 years were enumerated of which 2,587 (86.2%) were examined. Among them, 359 (13.9%) participants who had distance vision impairment were excluded from the NVI analysis.[22] The data of the

Table 1. Prevalence of near vision impairment (NVI) stratified by demographic variables.

	Total Participants (n = 2,228) n (%)†	Participants with no NVI (n = 1624)‡	Participants with NVI (n = 604) n (%)‡	p-value§
Age groups (y)				<0.001
40–49	921 (41.3)	706 (76.6)	215 (30.4)	
50–59	633 (28.4)	451 (71.2)	182 (40.3)	
60–69	442 (19.8)	327 (73.9)	115 (35.1)	
70 and above	232 (10.4)	140 (60.3)	92 (65.7)	
Gender				0.036
Men	1029 (46.2)	772 (75.0)	257 (33.2)	
Women	1199 (53.8)	852 (71.0)	347 (40.7)	
Education level				<0.001
No education	991 (44.5)	653 (65.8)	338 (51.7)	
Any education	1237 (55.5)	971 (78.4)	266 (27.3)	

†column percentage, ‡ row percentage , § chi-squared test.

remaining 2,228 participants were included in the NVI analysis. The mean ± standard deviation age of these participants was 54.0 ± 10.4 years; 53.8% were women and 44.5% had no formal education.

Near vision impairment (NVI)

The overall prevalence of NVI was 27.1% (95% CI: 25.2–29.0%; n = 604). This includes both uncorrected and inadequately corrected NVI. The prevalence of NVI was highest among those aged 70 and above (65.7%). The prevalence of NVI was least among the 40-49 age group (30.4%) (Table 1). Those with no formal education had significantly higher prevalence of NVI compared to any education group (51.7% versus 27.3%; $p <$ 0.001). Women had a higher prevalence of NVI compared to men (40.7% versus 33.2%: $p = 0.036$). Among the participants with NVI ($n = 604$), 357 (59.1%; 95% CI: 55.0–63.0%), 245 (40.6%; 95% CI: 36.6–44.5%), and two (0.3%; 95% CI: 0.04–1.1%) participants had mild, moderate, and profound NVI, respectively.

The multiple logistic regression analysis showed that participants aged ≥70 years had significantly higher odds for NVI (adjusted OR: 1.97; 95% CI: 1.45-3.70). Those with any education (adjusted OR: 0.75; 95% CI: 0.68-0.83) were at a lower risk for NVI. Women showed a higher risk for NVI; however, the difference was not statistically significant ($p = 0.121$) (Table 2).

Refractive error coverage (REC) and effective refractive error coverage (eREC) for near vision

Overall, the REC (%) and eREC (%) were 50.4% and 48.0%, respectively. The relative quality gap in near vision correction (RQG-REC (%)) was 5%. The met, under-met, and unmet need was stratified by different demographic variables is shown in Table 3. The eREC for near vision was lowest in the participants aged 70 years and older, among women and in those with any education.

Discussion

Over a quarter of the participants in Akividu region of Andhra Pradesh, India, had NVI. The prevalence of NVI is also widely reported in India (Table 4). Various epidemiological studies have reported the prevalence of NVI, ranging from 35.1% to 58.3% in the 40 years and older age groups in India compared to 27.1% in the present study.[11–13] A lower prevalence of NVI of 35% is also reported from Telangana compared to that of northern India.[6,13,31]

The reason for such low prevalence in these districts could be the variable economic situation and the availability and uptake of eye care services. Both the Krishna and West Godavari districts included in the current study are wealthy regions in the state of Andhra Pradesh. A lower prevalence of distance vision impairment was also noted in this region.[22] The prevalence of NVI also shows large variations globally (Table 4). A high prevalence is seen among the rural Chinese (67.3%) and Nepalese population (66.1%). In contrast, a low prevalence is noted in non-Indigenous Australians (21.6%).[5,32,33]

All these studies differed with regard to age groups, testing distance, monocular and binocular assessment, and the definition of NVI. Moreover, these studies were conducted at different time points and hence might be affected by the temporal trends because of service providers, literacy rate, socioeconomic status, and other lifestyle factors.

In the current study, NVI was defined on basis of N8 threshold similar to other studies from the region to facilitate cross comparison.[11–15] The N8 optotype corresponds to the font size used in the newspaper and most other text material. A threshold of N8 or N6 at a fixed distance of 40 cm is used in the recent review that reported the global trends in prevalence.[1] It is recommended to use a standard definition across studies that will help compare the prevalence across the regions more accurately.

The demographic associations with NVI are inconsistent across the population-based studies.[6,14,22] Similar to other studies in Andhra Pradesh and Telangana, a higher prevalence of NVI was noted among the older age groups in the present study.[6,14] While these findings are consistent with reported literature,[6] a few studies have reported an inconsistent associations with gender.[15,31] As reported earlier by Marmamula and colleagues, over half of the participants with NVI had moderate and mild impairment.[6,31] In this study, approximately 60% of the NVI cases had mild

Table 2. Associations between near vision impairment (NVI) and the demographic variables based on the multiple regression analysis.

	Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Age groups (years)				
40–49	Reference		Reference	
50–59	1.32 (1.05–1.66)	0.016	1.23 (0.98–1. 56)	0.078
60–69	1.15 (0.88–1.50)	0.281	1.09 (0.83–1.42)	0.51
70 and above	2.15 (1.59–2.92)	<0.01	1.97 (1.45–3.70)	<0.01
Gender				
Men	Reference		Reference	
Women	1.22 (1.01–1.47)	0.036	1.16 (0.96–1.41)	0.121
Education				
No education	Reference		Reference	
Any education	0.52 (0.43–0.63)	<0.01	0.75 (0.68–0.83)	<0.01

Table 3. Met need, under-met, and unmet need based on demographic variables.

	Met need ($n = 500$)	Under-met need ($n = 25$)	Unmet need ($n = 516$)	Refractive Error Coverage for near vision (%)[†]	Effective Refractive Error Coverage for near vision (%) [‡]	Relative Quality Gap - (%)[§]
Age group (years)						
40–49	207	9	200	51.9%	49.8%	5%
50–59	152	4	167	48.3%	47.0%	3%
60–69	102	4	91	53.8%	51.7%	4%
70 and above	39	8	58	44.8%	37.1%	18%
Gender						
Male	196	14	220	48.8%	45.6%	7%
Female	304	11	296	51.5%	49.7%	4%
Education						
No education	153	9	292	35.7%	33.7%	6%
Any education	347	16	224	61.8%	59.1%	5%
Cataract surgery in either eye						
Yes	104	8	72	60.9%	56.5%	6%
No	396	17	444	48.2%	46.2%	5%
Total	**500**	**25**	**516**	**50.4%**	**48.0%**	**5%**

[†]Refractive Error Coverage for Near Vision (REC) (%) = ((Met need+ Under-met need/(Met need + Under-met need + Unmet need)) × 100.
[‡]effective Refractive Errors Coverage for near vision (eREC) (%) = (Met need/(Met need + Under-met need + Unmet need)) × 100.
[§]Relative Quality Gap (RQG) = 1 - (eREC/REC) × 100.

Table 4. Near Vision Impairment and Near Vision Coverage from selected epidemiological studies in India and other countries.

Author and year (reporting)	Location	Examined (n)	Age group (mean (standard deviation) or median or range) (years)	Prevalence of Near Vision Impairment/Functional presbyopia (visual acuity criterion)	REC for near vision (%)
Rest of the world					
Lu Q (2011)[8]	Rural Northern China	1008	58.4 ± 10.7	67.3% (worse than or equal 20/50 (N8)	51.5%
Fekadu S, et al. (2020)[23]	Finote Selam, Northwest Ethiopia	549	46.4 ± 8.7	78.69% (worse than or equal N8 (6/12)	28.42%
Ntodie M et al. (2017)[24]	Cape Coast, Ghana	500	52.3 ± 10.3		25%
Laviers HR et al. (2010)[25]	Zanzibar, East Africa	381	≥40 years	89.2% (worse than N8)	17.6%
Ajibode HA et al. (2016)[26]	Sagamu, Ogun state, Nigeria	607	49.7 ± 11.4 years	80.9% (worse than N8)	28.4%
Naidoo KS et al. (2013)[27]	Durban, KwaZulu Natal, South Africa	1939	52 (interquartile range 45–60)	77.0% (worse than N8)	4.84%
Muhit M et al. (2018)[28]	Sirajganji, Bangladesh	1402	35–49 age group	62% (worse than N8)	3.2%
India					
Nirmalan PK (2006)[14]	Hyderabad, West Godavari, Adilabad and Mahbubnagar districts, Andhra Pradesh	5587	≥30 years	55.3% (worse than N8)	Not reported
Marmamula S (2009)[29]	Mahbubnagar district, Telangana	930	35–50 years	63.7% (worse than N8)	19%
Marmamula S et al. (2012)[15]	Fishing communities in Prakasam district, Andhra Pradesh	1560	≥40 years	42.0% (worse than N8)	11.1%
Marmamula S (2013)[12]	Cloth weaving communities in Prakasam district, Andhra Pradesh	2848	≥40 years	35.1% (worse than N8)	43.2%
Marmamula S et al. (2013)[30]	Homes for the aged centres in Prakasam district, Andhra Pradesh	494	≥50 years	55.1% (worse than N8)	23.9%
Marmamula S et al. (2014)[18]	Vijayawada region in Krishna district (Urban), Khammam, and Warangal, Andhra Pradesh	7378	≥40 years	34.5% (worse than N8)	27%
Marmamula S et al. (2021)[6]	Khammam and Warangal, Telangana, India	5357	53.5 ± 10.8 years	55.9% (worse than N8)	33.1% (eREC = 31.8%)
Malhotra S et al. (2022)[13]	Jhajjar, Haryana	3246	≥35 years	42.9% (worse than N8)	25.8%
Marmamula S (2021)[11]	Homes for the aged centres in Hyderabad, Telangana	826	≥60 years	51.2% (worse than N8)	Not reported
Current study (2022)	Akividu region West Godavari and Krishna districts, Andhra Pradesh	2228	≥40 years	27.1% (worse than N8)	50.4% (eREC = 48%)

impairment. It is likely that mild level of near vision loss may not have adversely affected their daily routine. However, this effect was not evaluated in this study.

The World Health Organization recommends an integrated people-centred eye care approach to achieve Universal Eye Health.[34] These include effective Refractive Error Coverage (eREC) for distance and near vision.[17,34] REC and eREC are critical indicators for assessing the coverage of refraction.[16] Higher coverage indicates a better availability and uptake of services. Discontinuation of spectacles because of poor fit and incorrect prescription has been widely reported from the studies in this region similar to the current study.[35,36] This could be partly attributed to quality of spectacles, spectacle dispensing and issues related to training of human resources involved in refraction.

In the Akividu region, REC and eREC (%) for near vision were 50.4% and 48%, respectively compared to the global estimate of eREC of 20.5% among those aged 50 years and older in the year 2021.[17] A previous study from the neighbouring state of Telangana reported eREC for near vision of 31.8% to 48% in this study.[6] Most studies reported on REC for near (Table 4). REC for near vision was higher in the current study compared to other regions in India.[6,13] REC of 50.4% was observed in this current study, a lower near vision coverage (26.5%) was reported in a study conducted in two

economically backward districts in the neighbouring state of Telangana.[31]

The difference between eREC and REC provides valuable insights regarding the quality of refraction and spectacle dispensing services. In this study, the relative quality gap in REC for near vision was 5% similar to 4.1% in Telangana.[6] While there is not set threshold for relative quality gap at this time, a lower gap is preferred which could indicate better quality of services. In addition to the quality of services, a higher quality gap may also be due to scratches on the lenses or outdated prescriptions. Technically, the quality gap does not define the quality of services and spectacles.

West Godavari and Krishna (Akividu region) are prosperous districts in Andhra Pradesh; however, the coverage was only 50%. This suggests need for educating people about NVI and encourage them to seek near vision correction services. A comprehensive eye health plan, encapsulating eye health promotion as an integral component, could be undertaken to improve the REC for near vision coverage in the region. Refraction and dispensing spectacles are best provided as part of primary eye care services. Strengthening these services and providing quality care that is affordable and accessible to at-risk groups such as elderly and those with lower socioeconomic status is essential to achieve universal eye health in this region.

The L V Prasad Eye Institute (LVPEI) established a secondary-level eye care centre to tackle this issue. The institute is also developing primary eye care centres in the Akividu region, catering to the eye care needs of 500,000 to one million people. This initiative aptly aligns with the goal of universal eye health coverage initiated by WHO.

This is the first population-based cross sectional study that investigated NVI and eREC for near vision prosperous rural region of Andhra Pradesh in South India. The findings from this study can be generalised to the population of the two districts because of the large sample size selected and the sampling method used. Near vision was recorded in outdoor conditions; therefore, the lighting was not standardised for all study participants which is a potential limitation. The participants with distance VI were excluded from the analysis.

A proportion of excluded participants could have had NVI in addition to distance VI resulting in an underestimation of the prevalence of NVI in our study. The prevalence of distance VI from this study is published.[22] The results from this study on NVI will supplement the earlier findings on distance VI and provide a comprehensive burden of all VI in the region.

In conclusion, NVI is common among the 40 and above age groups in the Akividu region. The true prevalence of NVI in the community could be even higher if those with distance vision impairment were also included. Most of the NVI can be managed by dispensing a pair of near-vision spectacles with strategic planning and robust primary eye care. This study provided baseline data on key indicators in planning and monitoring the progress towards achieving universal eye health in the region.

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