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Complete List of Authors:	Malhotra, Sumit; Centre for Community Medicine Vashist, Praveen Kalaivani, Mani; All India Institute of Medical Sciences, Biostatistics Gupta, Noopur; All India Institute of Medical Sciences, Ophthalmology Senjam, Suraj; All India Institute of Medical Sciences, Community Ophthalmology Rath, Rama; AIIMS, Community Medicine Gupta, Sanjeev; All India Institute of Medical Sciences, Community Medicine
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Prevalence and causes of visual impairment amongst older adults in a rural area of North India

Sumit Malhotra[1], Praveen Vashist[2], Mani Kalaivani[3], Noopur Gupta[4], Suraj Singh Senjam[2], Ramashankar Rath[1], Sanjeev Kumar Gupta[1]

Author Affiliations:

1. Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi
2. Community Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi
3. Department of Biostatistics, All India Institute of Medical Sciences, New Delhi
4. Department of Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi

Corresponding Author:

Dr. Sumit Malhotra,

Associate Professor,

Centre for Community Medicine,

All India Institute of Medical Sciences,

New Delhi-110029,

India

E-mail ID: drsumitaiims@gmail.com

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Abstract (Word Count:228)

OBJECTIVES

To determine the prevalence, causes and associated factors for visual impairment in rural population of Jhajjar district, Haryana, north India.

METHODS

A population-based, cross-sectional study was conducted in two blocks of Jhajjar district. A total of thirty four villages were selected using Probability Proportionate to Size (PPS) sampling method. Adults aged 50 years and above, were selected using compact segment cluster sampling approach. Presenting visual acuity using LogMAR E chart was measured along with collection of other demographic details as part of the house-to-house survey. Subjective refraction and torch light examination was performed at a clinic site within the village to ascertain visual impairment and its cause.

RESULTS

Out of 2025 enumerated adults, 1690 (83.5%) were examined at the household level and 1575 (78%) completed all study procedures. The prevalence of visual impairment was found to be 24.5% (95% CI: 21.1, 26.3) and blindness was 5% (95% CI: 3.9, 6.1). The most common causes of visual impairment were uncorrected refractive errors (50%) and cataract (37%). The visual impairment in study participants was found to be associated with age, gender, marital and educational status.

CONCLUSIONS

We found a high prevalence of visual impairment including blindness in this study population. Augmenting primary and secondary eye care services encompassing refractive

and cataract surgical interventions will be imperative to tackle the burden of visual impairment in this rural population.

Strengths and Limitations of this study

- It is a population based study using standard accepted procedures and is replicable in similar settings.
- We have reported prevalence of unilateral visual impairment also.
- There might be underestimation of posterior segment pathologies as their diagnosis is difficult to ascertain in an undilated pupil.
- This study is done in rural population, thus results might not be generalizable to urban settings.

Introduction

Eye diseases, vision loss and resulting disability remain a major public health concern. It has been estimated that globally, 285 million people are visually impaired, out of which 39 million are blind [1]. Though there has been decline noted in prevalence of blindness over recent times, blindness has actually increased in absolute terms owing to increase in numbers of older people with rise in life expectancy [2]. Much of this global burden is distributed unevenly and some regions have higher burden compared to others. The prevalence of blindness and visual impairment in South East Asia region of World Health Organization (that includes India) has been estimated to be three times higher than the global prevalence figures [3]. It has been reported that more than half of the world's blind reside in five nations namely India, China, Indonesia, Pakistan and Nigeria. India has estimated 8.3 million blind population (95% CI: 6.6, 9.7 million). Also, India contributed to 31% of global burden of moderate and severe visual impairment [2]. Much of the load of blindness (80%) has been attributed to avoidable causes that can be either prevented or corrected easily. The maximum visual impairment is seen in older adult population i.e. after 50 years of age. 82% of those blind and 65% of those with moderate or severe visual impairment are older than 50 years [4].

Sustainable development goals have envisioned achieving optimal health status at all life spans [5]. The global eye health action plan 2014-19, endorsed by sixty-sixth World Health Assembly, charted out broad eye health programmatic components. A vital target was set to achieve reduction in prevalence of avoidable visual impairment by one quarter till year 2019 against baseline values in year 2010. One of the key objectives included under this plan was to undertake epidemiological surveys on visual impairment at regular intervals nationally and sub-nationally, so as to generate evidence about magnitude and causes of visual impairment [6]. The last nation-wide blindness assessment undertaken in India was published

way back in the year 2008. Though there has been recent increase in epidemiological research on visual impairment, these studies are largely done in southern part of India. There is need to generate population level evidence on visual impairment in northern states of India for efficient planning of eye care services, where studies in this context are lacking especially from rural parts. Against this background, the current study was done to determine prevalence and causes of visual impairment in older adults in a rural area of north India. We also report here the common associated factors with visual impairment in the study population.

Materials and Methods

This was a population-based cross-sectional survey.

Study Setting

The study was conducted in Jhajjar district of north India. The Jhajjar district is one of the twenty one districts of the state of Haryana, situated at 65 km distance from National Capital Territory of Delhi. The total population of the district was 9,56,907 as per census 2011. The district comprised predominantly rural population (75%) with sex ratio highly skewed towards males (861 females per 1000 males). The study was done in two of the five blocks, namely Bahadurgarh and Jhajjar, selected randomly from all the five blocks. Rural population was only considered within these blocks for purpose of this study. A list of villages in these blocks was prepared and villages were arranged according to the increasing size of population. Selection of villages was done based on Probability Proportional to Size (PPS) sampling method giving weightage according to population size. Thirty four villages were selected in these two blocks using this strategy. Each village was considered as a cluster and compact cluster sampling strategy was employed for selection of households within each cluster. Each selected village was broken down to compact segments of 400-600 population. One compact segment was selected randomly using concealed envelopes and all adults in the target age more than or equal to 50 years were enumerated. It was ensured that a minimum of 45-50 participants in the target age group were enumerated in each selected segment for examination. The data was collected during January to May 2014.

Sample Size

We assumed prevalence of visual impairment in adults more than 50 years as 18.5% [7]. With relative precision of 15%, design effect of 1.5 to account for cluster design and 25%

non-response, 1469 participants were required in this current study to meet the objective of determining prevalence of visual impairment in this study.

Ethics statement

The ethics approval for conduct of the study was obtained from Institute Ethics Committee of All India Institute of Medical Sciences (AIIMS), New Delhi. The study procedures conformed to the principles laid out by Declaration of Helsinki.

Examination teams

Two study teams were engaged in data collection and examination. Each team comprised of one Ophthalmic Technician (OT), Social Worker (SW) and Health Assistant (HA). The personnel selected for this epidemiological research work were rendering primary eye care in the vision clinics for more than two years. The teams were sensitized and trained in all procedures related to data collection and examination. The inter-observer correlation (Kappa) coefficient was found 0.7-0.8 for same level of observers.

At first level, house-to-house visit was done by social worker and health assistant. Demographic details, ocular disease history (past cataract surgeries and spectacle use) and, presenting distance visual acuity was measured for eligible study participants. The presenting visual acuity was measured using logMAR "E" chart with five 6/12 optotypes on the vision placard. The visual acuity measurement was done at distance of four meters, outdoors and in shade on bright and sunny days. Adequate care was given to avoid reflections and glare on the vision placard. Presenting visual acuity was considered as vision with spectacles if using spectacles for distance vision. All participants with presenting visual acuity<6/12 in either eye, adults using spectacles and those with previous cataract surgery were referred to a temporary makeshift clinic within a village building where Ophthalmic Technicians (OTs) performed detailed eye assessment. The ophthalmic technicians repeated the visual acuity

assessment using logMAR tumbling E charts and performed the torch light examination, and non-cycloplegic refraction. Lens was assessed using torch light. Common causes of visual impairment viz uncorrected refractive errors, cataract, central corneal opacity, and 'others' were documented by ophthalmic technicians.

Quality assurance and standardization of all study procedures and equipment was done throughout the conduct of this study. Pilot testing of all procedures was done in one of the villages that was not part of the study clusters. The study investigating team including the epidemiologist and ophthalmologist supervised data collection and examination procedures. Random checks to households was done to examine the information collected from household members and their visual status. The ophthalmologist also examined randomly eyes of visually impaired persons to cross check findings of ophthalmic assistants. Ten percent of all participants' forms and recorded findings were rechecked within the study cluster.

Operational definitions: Various terms used were defined as below:

Older adults: Participants≥ 50 years of age.

Below poverty line: was considered for an adult when monthly income was less than US$ 4.6 [8], and was confirmed by presence of below poverty line (BPL) ration card by the family.

Visual impairment (VI): This was defined as per definitions suggested by World Health Organization (WHO) [9]. Visual impairment was considered in this study when presenting visual acuity was less than 6/18 in the better eye. It included moderate visual impairment, severe visual impairment and blindness. Moderate visual impairment was defined as presenting visual acuity<6/18 and ≥6/60 in the better eye. Severe visual impairment was defined as presenting visual acuity<6/60 and ≥3/60 in the better eye.

Blindness: was defined as presenting visual acuity<3/60 in the better eye.

Unilateral visual impairment: Presenting visual acuity worse than 6/18 in one eye but better than or equal to 6/18 in other eye. Those with bilateral visual impairment were not considered.

Unilateral Blindness: Presenting visual acuity worse than 3/60 in one eye but better than or equal to 6/18 in other eye. Those with bilateral visual impairment were not considered. Uncorrected Refractive Error: When the presenting visual acuity was less than 6/18 but improved to 6/18 or better with refraction.

Cataract: Opacity of the crystalline lens in the pupillary area, as seen with torchlight.

Central Corneal Opacity: Easily visible corneal opacity present over the pupil.

Other causes of visual impairment: all causes other than mentioned above were included in this category.

For ascertaining cause of visual impairment, first the cause was recorded for each eye separately and then for the person. In a possible scenario of two causes for visual impairment present for each eye, one that was more avoidable that is either preventable or treatable, was recorded. For uncorrected refractive error and untreated cataract present in same person, uncorrected refractive error was recorded as principle cause for visual impairment. This is as per suggested methodology of WHO for surveys on blindness and visual impairment [10].

Data management and analysis

Data entry was performed using Microsoft Access based database with in-built consistency and validation checks. Statistical analysis was carried out using Stata 12.0 (Stata Corp., College Station, TX, USA). Data were presented as numbers and percentages. Prevalence estimates were computed and presented along with 95% confidence intervals. These have been adjusted for cluster design. Multivariate logistic regression analysis was performed for

determining associated factors using survey analysis (*svy:logit* command) to account for cluster design and confounding. The results were presented as odds ratios and 95% confidence intervals.

Results

A total of 2025 adults aged ≥50 years were enumerated in 34 study clusters of rural Jhajjar. Out of these 1690 (83.5%) were examined at household level, and 1575 (78%) completed all study procedures whose vision details have been included in this study. The socio-demographic characteristics of the enumerated and covered participants is shown in Table 1. The mean age (SD) of the examined adults was 62.9 (9.7) years, and was similar for both men [63.1 (9.9) years] and women [62.9 (9.5) years]. Out of all the examined adults, 817(52%) were illiterate, 1085 (69%) were engaged in house work and 1156 (73%) were married.

Prevalence of visual impairment and blindness

A total of 386 participants were found to be visually impaired yielding a prevalence of 24.5% (95% CI: 21.1, 26.3) as shown in Table 2. The predominant category was moderate visual impairment as seen in 277 individuals, with a prevalence as 17.6% (95% CI: 14.9, 18.6). The blindness was found in 79 participants with prevalence of 5.0% (95% CI: 3.9, 6.1).

Causes of visual impairment and blindness

Eighty seven percent of visual impairment in our study population was due to uncorrected refractive errors (50%) and cataract (37%) (Table 3). Cataract was the predominant cause contributing to severe visual impairment (70%) and blindness (57%) respectively. The central corneal opacities resulted in 65% of visual impairment and 19% of blindness. Other causes contributed to 13% of visual impairment and 34% of blindness respectively.

Factors associated with visual impairment and blindness

On multivariable logistic regression analysis (Table 4), visual impairment was found to be associated with increasing age. Adults aged 60-69 years and more than equal to 70 years had

four times [aOR 3.6, 95% CI: 2.6, 5.1] and six times [aOR 6.1, 95% CI: 4.3, 8.7] significantly higher odds of visual impairment than adults aged 50-59 years. Women compared to men were found to be positively associated with visual impairment on bivariate analysis, but after adjusting for other factors on multivariable analysis, were found to be negatively associated [a OR 0.7, 95% CI: 0.5, 0.9]. Single adults compared to married adults were found to have two times higher odds of visual impairment [aOR 1.6, 95% CI: 1.1, 2.2]. Education was also found to be significantly associated with visual impairment, increasing level of education was found to be protective. Compared to illiterate adults, the odds of visual impairment were lesser amongst those educated up to primary level [aOR 0.6, 95% CI: 0.5, 0.8], secondary level [aOR 0.4, 95% CI: 0.3,0.5] and senior secondary level [a OR 0.4, 95% CI: 0.2, 0.7].

Similar factors like increasing age, marital status, and educational levels were found to be associated significantly with blindness.

Unilateral Visual Impairment - prevalence, causes and associated factors

A total of 227 participants were identified with unilateral visual impairment, with a prevalence as 14.4% (95% CI: 12.3, 16.5). The most common cause was uncorrected refractive errors in 173 (76%), cataract in 28 (12%), central corneal opacity in 16 (7%), others in 10 (4%) adults respectively. On multivariate logistic regression analysis (Table 5), the odds of unilateral visual impairment were found to be three times higher in adults aged 60-69 years [aOR 2.7, 95% CI: 1.7,4.1]; and six times higher in adults aged ≥70 years [aOR 5.6, 95% CI: 3.5, 8.8] respectively compared to adults aged 50-59 years. The odds of unilateral visual impairment were found to be 50% lesser in adults educated upto primary level compared to illiterate adults [aOR 0.5, 95% CI: 0.3,0.9]. Also, the odds of unilateral

visual impairment were two times higher in adults belonging to below poverty line compared to those who belonged to above poverty line families [aOR 1.48, 95% CI: 1.0, 2.2].

Discussion

To best of our knowledge, this was the first population level assessment of visual impairment and blindness conducted within district Jhajjar of state Haryana. The prevalence of visual impairment in our study sample was found to be 24.5% (95% CI: 21.1, 26.3). This is almost similar to recent population level estimates from southern states of India. The reported prevalence of visual impairment in adults aged ≥ 50 years in a newly formed southern state of Telengana was 23.5% (95% CI: 22.1, 25.0) [11]. The Andhra Pradesh Rapid Assessment of Visual Impairment study (AP-RAVI) that included both rural and urban clusters, estimated prevalence of VI as 23.1 (95% CI: 21.8, 24.5) [12]. These studies followed almost similar methodology as ours especially in regard to ocular examination. In an urban setting of Delhi within north India, the prevalence of visual impairment was reported slightly lower as 18.5% (95% CI: 16.4, 20.6 [7]. Our study included all rural clusters and it has been reported earlier that the magnitude of visual impairment is higher in rural areas than urban areas. The differences in rural and urban clusters might be ascribed to differences in accessibility and availability of eye care services and personnel. There has not been much progress in reduction of magnitude of visual impairment as the nationwide study (16 districts, predominantly rural) published in year 2008 that estimated visual impairment as 25% [13]. Evidence from other studies has been variable and the prevalence of visual impairment in these studies ranged from 18% to 34% [14,15,16] . The prevalence in these studies differed owing to variations in study location, methods utilized in visual assessment, sample size, access to eye care services and socio-economic variations of the population studied. The prevalence estimate for visual impairment reported for other Asian countries is also variable and is reported lower than Indian estimates- Sri Lanka [17], China [18], Bangladesh [19], Malaysia [20], Timor-Leste [21] and Nepal [22].

In our study, 87% of visual impairment was contributed by two causes- uncorrected refractive errors (50%) followed by cataract (37%). The blindness and severe visual impairment were predominantly contributed by cataract. Fifty seven percent of blindness and seventy percent of severe visual impairment was contributed by cataract. This is consistent with other studies [7,11,12] where 80-90% of visual impairment is attributed to these two causes. Globally, 75% of the visual impairment is due to refractive errors and cataract [1]. Uncorrected refractive errors has been the leading cause of moderate and severe visual impairment in the world with proportions ranging between 43 to 48%, except in south Asia (that includes India) where proportion was high as 65% (95% CI: 62,72) [23]. In year 2010, cataract was responsible for 33 % (South Asia: 42%) of blindness and 18 % (South Asia: 21%) of global moderate and severe visual impairment [24].

Increasing age is one the commonest associated factor for visual impairment [25, 26, 27, 28]. In our study, elderly adults aged 70 years and above had the highest odds of visual impairment compared to adults in the fifth decade. There have been variations in association of gender and visual impairment in different studies depending on study location and sample studied. In our study, on multivariate analysis, women were found to have 30% lesser odds for visual impairment than men. Similar finding has been reported from a south Indian study on visual impairment that included marine fishing population as sample [29]. Contrastingly, some studies in Indian settings have reported no association with gender [12] or women to have higher risk for visual impairment [7,13, 30]. We found visual impairment to be associated with single adults compared to married adults, possibly due to lack of support system and access to eye care services. Visual impairment in our study was found to be lower in those who had completed higher schooling levels. Previous studies have reported higher prevalence of visual impairment among those who were not educated [31,32,33,34] . This could be due to higher visual need, demand and better awareness and accessibility for eye

care services by more educated people in our sample as postulated in other study from Indian setting [35].

To represent the complete burden of visual impairment in our study population, we also computed the prevalence of unilateral visual impairment. Our prevalence estimate of 14% was slightly higher than what had been reported earlier in Andhra Pradesh as 11.3% (95% CI: 10.5, 12.1). This study had included adults more than equal to 40 years from both rural and urban clusters [36]. The unilateral visual impairment in our study was found to be associated with age, education and poverty status, consistent with other studies [36,37, 38]. It is postulated that socio-economic factors influence the health seeking behaviour of individuals in terms of accessibility and affordability for eye care services. Also, visual impairment can contribute to the individuals' and their families' socioeconomic status [37]. The persons with unilateral visual impairment are also affected by poor quality of life [39,40, 41] and correcting it has immense benefits [42].

Our study has programmatic implications. Extrapolating our high prevalence estimates for visual impairment in rural population of 0.7 million size within Jhajjar district, there were 27,034 visually impaired adults above the age group 50 yrs with uncorrected refractive errors and 12,580 visually impaired adults with cataract. These can easily be treated by cataract surgeries and provision of refractive services, including uptake of spectacles through integrated service delivery models for primary and secondary eye care [43]. Recently, the programme in Indian settings has been renamed and included visual impairment, giving due importance to curb the burden related to visual impairment [44].

In conclusion, the prevalence of visual impairment in rural Jhajjar was found to be high as 24% and blindness as 5% in adults aged 50 years and above. The most common causes of visual impairment were uncorrected refractive errors and cataract.

The prevalence of unilateral visual impairment was 14%. Adequate health system response at primary and secondary care levels is needed to tackle the unfinished agenda of visual impairment in this population.

Contributor ship statement

SM, PV conceived and designed the study with additional inputs from NG, SSS and SKG. SM, PV, NG, SSS supervised the overall conduct and data collection process for the study. MK, RSS managed the dataset and analysed it with additional inputs from SM, PV, SKG. SM wrote the initial draft of the manuscript. All authors contributed to the critique and modification of the manuscript, read and approved the final version.

Competing Interests: None

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Data sharing statement

All unpublished data related to this research project are available with the authors and can be requested by emailing to drsumitaiims@gmail.com

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Table 1. Socio-demographic Characteristics

Variable		Enumerated Adults n=2025 (%)	Examined Adults n=1575 (%)
Age (Years)	50-59	771 (38)	584 (37)
	60-69	745 (37)	584 (37)
	≥70	509 (25)	407 (26)
Gender	Men	973 (48)	678 (43)
	Women	1052 (52)	897 (57)
Marriage	Married	1511 (75)	1156 (73)
	Single (Unmarried/ Widower)	514 (25)	419 (27)
Occupation	Housework	1305 (64)	1085 (69)
	Labour- Agricultural/ Non-Agricultural	326 (16)	218 (14)
	Office/ Skilled work	166 (8)	99 (6)
	Unemployed/ Retired	228 (12)	173 (11)
Education	Illiterate	1017 (50)	817 (52)
	Primary (Upto 5th Class)	272 (13)	221 (14)
	Secondary (Upto 10th Class)	600 (30)	452 (29)
	Senior Secondary and above	136 (7)	85 (5)
Poverty Line (PL)	Above PL	1668 (82)	1294 (82)
	Below PL	357 (18)	281 (18)

Table 2. Categories of Visual Impairment

	PVA	Number	Percentage	95% CI
Normal	≥6/18	1189	75.5	
Visual Impairment	<6/18	386	24.5	21.1, 26.3
Moderate VI	<6/18 – 6/60	277	17.6	14.9, 18.6
Severe VI	<6/60-3/60	30	1.9	0.9, 2.8
Blindness	<3/60	79	5.0	3.9, 6.1

VI: Visual Impairment; PVA- Presenting Visual Acuity

Table 3. Causes of visual impairment

S.No	Cause	Mild Visual Impairment n (%)	Moderate Visual Impairment n (%)	Severe Visual Impairment n (%)	Blindness n (%)
1	Uncorrected Refractive Errors	192 (49.7)	182 (65.7)	03 (10.0)	07 (8.9)
2	Cataract	143 (37.1)	77 (27.8)	21 (70.0)	45 (56.9)
3	Central Corneal Opacity	26 (6.7)	11 (4.0)	03 (10.0)	12 (15.2)
4	Others	25 (6.5)	07 (2.5)	03 (10.0)	15 (18.9)
	Total	386	277	30	79

Table 4. Bivariate analysis and Multivariate analysis for Visual Impairment

Variable		Participants n (1575)	Visual impairment (n) %	Unadjusted Odds Ratio (95% CI)	p value	Adjusted Odds Ratio (95% CI)	p value
Age (Years)	50-59	584	46 (08)	1.0		1.0	
	60-69	584	162 (28)	4.5 (3.2, 6.3)	<0.001	3.6 (2.6, 5.1)	<0.001
	>70	407	178 (44)	9.1 (6.6, 12.6)	<0.001	6.1 (4.3, 8.7)	<0.001
Gender	Men	678	150 (22)	1.0		1.0	
	Women	897	236 (26)	1.3 (1.0, 1.6)	0.10	0.7 (0.5, 0.9)	0.02
Marriage	Married	1156	226 (20)	1.0		1.0	
	Single (Unmarried/ Widower)	419	160 (38)	2.5 (1.9, 3.3)	<0.001	1.6 (1.1, 2.2)	0.007
Occupation	Housework	1085	289 (27)	1.0		1.0	
	Labour-Agricultural/ Non-Agricultural	218	39 (18)	0.6 (0.4, 0.9)	0.007	1.1 (0.7, 1.7)	0.75
	Office/ Skilled work	99	06 (06)	0.2 (0.1, 0.5)	0.001	0.5 (0.2, 1.5)	0.22
	Unemployed/ Retired	173	52 (30)	1.2 (0.9, 1.6)	0.29	0.9 (0.7, 1.3)	0.67
Education	Illiterate	817	271 (33)	1.0		1.0	
	Primary (Upto 5th Class)	221	46 (21)	0.5 (0.4, 0.7)	<0.001	0.6 (0.5, 0.8)	0.003
	Secondary (Upto 10th Class)	452	59 (13)	0.3 (0.2, 0.4)	<0.001	0.4 (0.3, 0.5)	<0.001
	Senior Secondary and above	85	10 (12)	0.3 (0.1, 0.5)	<0.001	0.4 (0.2, 0.7)	0.003
Poverty Line (PL)	Above PL	1294	298 (23)	1.0		1.0	
	Below PL	281	88 (31)	1.5 (1.1, 2.1)	0.02	1.4 (0.9, 2.1)	0.11

Table 5. Bivariate analysis and Multivariate analysis for Unilateral Visual Impairment

Variable		Participants n (1189)*	Unilateral Visual impairment (n) %	Unadjusted Odds Ratio (95% CI)	p value	Adjusted Odds Ratio (95% CI)	p value
Age (Years)	50-59	538	47 (09)	1.0		1.0	
	60-69	422	93 (22)	2.9 (1.9, 4.4)	<0.001	2.7 (1.7, 4.1)	<0.001
	≥70	229	87 (38)	6.4 (4.4, 9.3)	<0.001	5.6 (3.5, 8.8)	<0.001
Gender	Men	528	86 (16)	1.0		1.0	
	Women	661	141 (21)	1.4 (1.0, 1.9)	0.09	1.1 (0.7, 1.7)	0.59
Marriage	Married	930	151 (16)	1.0		1.0	
	Single (Unmarried/ Widower)	259	76 (29)	2.1 (1.5, 3.0)	0.04	1.4 (0.9, 2.1)	0.09
Occupation	Housework	796	165 (21)	1.0		1.0	
	Labour-Agricultural/Non-Agricultural	179	27 (15)	0.7 (0.4, 1.1)	0.29	1.3 (0.7, 2.4)	0.32
	Office/ Skilled work	93	07 (08)	0.3 (0.1, 0.6)	0.03	0.8 (0.4, 1.8)	0.59
	Unemployed/ Retired	121	28 (23)	1.2 (0.7, 1.9)	0.75	0.9 (0.6, 1.6)	0.77
Education	Illiterate	546	139 (26)	1.0		1.0	
	Primary (Upto 5th Class)	175	22 (13)	0.4 (0.3, 0.6)	0.005	0.5 (0.3, 0.9)	0.01
	Secondary (Upto 10th Class)	393	58 (15)	0.5 (0.4, 0.7)	0.06	0.8 (0.5, 1.3)	0.32
	Senior Secondary and above	75	08 (11)	0.3 (0.2, 0.8)	0.08	0.6 (0.2, 1.3)	0.16
Poverty Line (PL)	Above PL	996	179 (18)	1.0		1.0	
	Below PL	193	48 (25)	1.5 (1.1, 2.1)	0.16	1.5 (1.0, 2.2)	0.04

*- 386 participants with bilateral visual impairment have been excluded for unilateral visual impairment

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8,9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7,8,9*
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6,7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	11,12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11,12,13

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12,13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and causes of visual impairment amongst older adults in a rural area of North India- A cross-sectional study

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Prevalence and causes of visual impairment amongst older adults in a rural area of North India- A cross-sectional study

Sumit Malhotra[1], Praveen Vashist[2], Mani Kalaivani[3], Noopur Gupta[4], Suraj Singh Senjam[2], Ramashankar Rath[1], Sanjeev Kumar Gupta[1]

Author Affiliations:

1. Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi
2. Community Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi
3. Department of Biostatistics, All India Institute of Medical Sciences, New Delhi
4. Department of Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi

Corresponding Author:

Dr. Sumit Malhotra,

Associate Professor,

Centre for Community Medicine,

All India Institute of Medical Sciences,

New Delhi-110029,

India

E-mail ID: drsumitaiims@gmail.com

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Abstract (Word Count: 267)

OBJECTIVES

To determine the prevalence, causes and associated factors for visual impairment in rural population of Jhajjar district, Haryana, north India.

METHODS

A community-based, cross-sectional study was conducted in two blocks of Jhajjar district. A total of thirty four villages were selected using Probability Proportionate to Size (PPS) sampling method. Adults aged 50 years and above, were selected using compact segment cluster sampling approach. Presenting visual acuity using LogMAR E chart was measured along with collection of other demographic details as part of the house-to-house survey. Subjective refraction and torch light examination was performed at a clinic site within the village to ascertain visual impairment and its cause. Visual impairment was considered when presenting visual acuity was less than 6/18 in the better eye. Common causes of visual impairment viz uncorrected refractive errors, cataract, central corneal opacity and others were noted by ophthalmic technicians. Descriptive analysis was undertaken. Multivariate logistic regression analysis was performed for determining associated factors with visual impairment.

RESULTS

Out of 2025 enumerated adults, 1690 (83.5%) were examined at the household level and 1575 (78%) completed all study procedures. The prevalence of visual impairment was found to be 24.5% (95% CI: 21.1, 26.3) and blindness was 5% (95% CI: 3.9, 6.1). The most common causes of visual impairment were uncorrected refractive errors (50%) and cataract (37%). The visual impairment in study participants was found to be associated with age, gender, marital and educational status.

CONCLUSIONS

Visual impairment is still a public health problem in rural population of Jhajjar district, Haryana. Provision of spectacles and cataract surgical services are simple interventions to address this issue.

Strengths and Limitations of this study

- It is a community based study using rapid survey procedures.
- It is first assessment for visual impairment in Jhajjar district, Haryana within north India and generates evidence for programmatic action.
- There might be underestimation of posterior segment pathologies as their diagnosis is difficult to ascertain in an undilated pupil.
- This study is done in rural population, thus results might not be generalizable to urban settings.

Introduction

Eye diseases, vision loss and resulting disability remain a major public health concern [1]. It has been estimated that globally, 253 million people are visually impaired, out of which 36 million are blind and 217 million have moderate to severe visual impairment [2]. Though there has been decline noted in prevalence of blindness over recent times, blindness has actually increased in absolute terms owing to increase in numbers of older people with rise in life expectancy [2]. Much of this global burden is distributed unevenly and some regions have higher burden compared to others. The south Asia (that includes India) region contributes maximum to global blindness and moderate or severe visual impairment burden. It is estimated that south Asia has 12 million blind people and 61 million people with moderate or severe visual impairment [2]. The age standardized prevalence of moderate or severe visual impairment in South Asia is three times higher than high-income regions [2]. Much of the load of blindness (80%) has been attributed to avoidable causes that can be either prevented or corrected easily [1]. The maximum visual impairment is seen in older adult population i.e. after 50 years of age- 86% of those blind and 80% of those with moderate or severe visual impairment are older than 50 years [2]. The global eye health action plan 2014-19, endorsed by sixty-sixth World Health Assembly, charted out broad eye health programmatic components. A vital target was set to achieve reduction in prevalence of avoidable visual impairment by one quarter till year 2019 against baseline values in year 2010. One of the key objectives included under this plan was to undertake epidemiological surveys on visual impairment at regular intervals nationally and sub-nationally, so as to generate evidence about magnitude and causes of visual impairment [3].

According to recent global estimates, India records one of the highest prevalence of visual impairment. The age standardized prevalence of blindness and moderate or severe visual impairment in India is 4% and 17% respectively amongst adults aged 50 and more [2].

The last nation-wide blindness assessment undertaken in India was published way back in the year 2008 [4]. Though there has been recent increase in epidemiological research on visual impairment, these studies are largely done in southern part of India. There is need to generate population level evidence on visual impairment in northern states of India for efficient planning of eye care services, where studies in this context are lacking especially from rural parts. Against this background, the current study was done to determine prevalence and causes of visual impairment in older adults in a rural area of north India. We also report here the common associated factors with visual impairment in the study population.

Materials and Methods

This was a community-based cross-sectional survey.

Study Setting

The study was conducted in Jhajjar district of north India. The Jhajjar district is one of the twenty one districts of the state of Haryana, situated at 65 km distance from National Capital Territory of Delhi. The total population of the district was 9,58,405 as per census 2011[5]. The district comprised predominantly rural population (75%) with sex ratio highly skewed towards males (862 females per 1000 males). The study was done in two of the five blocks, namely Bahadurgarh and Jhajjar, selected randomly from all the five blocks. Rural population was only considered within these blocks for purpose of this study as rural areas are reported to have more burden of visual impairment than urban counterparts [4]. A list of villages in these blocks was prepared and villages were arranged according to the increasing size of population. Selection of villages was done based on Probability Proportional to Size (PPS) sampling method giving weightage according to population size. Thirty four villages were selected in these two blocks using this strategy. Each village was considered as a cluster and compact cluster sampling strategy was employed for selection of households within each cluster. Each selected village was broken down to compact segments of 400-600 population. One compact segment was selected randomly using concealed envelopes and all adults in the target age more than or equal to 50 years were enumerated. It was ensured that a minimum of 45-50 participants in the target age group were enumerated in each selected segment for examination. The data was collected during January to May 2014.

Sample Size

We assumed prevalence of visual impairment in adults more than 50 years as 18.5% [6]. This was the most recent estimate available from northern India. With relative precision of 15%,

design effect of 1.5 to account for cluster design and 25% non-response, 1469 participants were required in this current study to meet the objective of determining prevalence of visual impairment.

Ethics statement

The ethics approval for conduct of the study was obtained from Institute Ethics Committee of All India Institute of Medical Sciences (AIIMS), New Delhi. The study procedures conformed to the principles laid out by Declaration of Helsinki. The local consent was taken from the village leaders for participation at the cluster level. Participants were explained about study aspects through participant information sheets designed in local language. Sequentially, written informed consent was obtained from head of household for all participants within the household that were enrolled in this study. All participants detected with visual impairment were referred to the ophthalmic outpatient department at AIIMS, Jhajjar complex.

Examination teams

Two study teams were engaged in data collection and examination. Each team comprised of one Ophthalmic Technician (OT), Social Worker (SW) and Health Assistant (HA). The personnel selected for this epidemiological research work were rendering primary eye care in the vision clinics for more than two years including vision examination by LogMAR charts. The ophthalmic technicians were degree/ diploma holders in optometry. The teams were sensitized and trained in all procedures related to data collection and examination. A three day training including field practice session was conducted for all study personnel by epidemiologist and ophthalmologist and included components of enumeration of participants and eliciting relevant details as per data collection instruments, vision examination and

detailed work up for visually impaired persons for ascertaining the cause. The inter-observer correlation (Kappa) coefficient was found 0.7-0.8 for same level of observers.

At first level, house-to-house visit was done by social worker and health assistant. The social worker took written informed consent from head of households and explained all study procedures to all study participants, built adequate rapport and coordinated referral of participants for detailed eye work up by ophthalmic technicians. Demographic details, ocular disease history (past cataract surgeries and spectacle use) and, presenting distance visual acuity was measured for eligible study participants by the health assistant with the help of social worker. The presenting visual acuity was measured using screening chart corresponding to five "E" 6/12 optotypes. Correct identification of four letters out of five was considered as pass criteria. The visual acuity measurement was done at distance of four meters, outdoors and in shade on bright and sunny days. Adequate care was given to avoid reflections and glare on the vision placard. Presenting visual acuity was considered as vision with spectacles if using spectacles for distance vision. All participants with presenting visual acuity<6/12 in either eye, adults using spectacles and those with previous cataract surgery were referred to a temporary makeshift clinic within a village building where Ophthalmic Technicians (OTs) performed detailed eye assessment. The ophthalmic technicians repeated the visual acuity assessment using retro illuminated conventional logMAR tumbling E charts and performed the torch light examination, and non-cycloplegic refraction. Lens was assessed using torch light. A pupil that clearly appeared grey or white when examined with oblique light was noted as obvious lens opacity and cataract [7]. Common causes of visual impairment viz uncorrected refractive errors, cataract, central corneal opacity, and 'others' were documented by ophthalmic technicians.

Quality assurance and standardization of all study procedures and equipment was done throughout the conduct of this study to minimize errors during the data collection. Pilot

testing of all procedures was done in one of the villages that were not part of the study clusters. The study investigating team including the epidemiologist and ophthalmologist, supervised all data collection and examination procedures. The epidemiologist was responsible for finalization of study compact segment within each cluster village and finalization of central location for clinical examination to maximize access for all participants. Visitors to households and those people outside the selected compact segment were not included in the study procedures to minimize bias and estimate of visual impairment. Random checks to households were done to examine the information collected from household members and their visual status. The ophthalmologist also examined randomly eyes of visually impaired persons to cross check findings of ophthalmic assistants. Ten percent of all participants' forms and recorded vision findings were rechecked within the study cluster by the epidemiologist and ophthalmologist, including those that were detected with normal visual acuity at the initial time of screening at household level.

Operational definitions: Various terms used were defined as below:

Older adults: Participants≥ 50 years of age [2].

Below poverty line: was considered for an adult when monthly income was less than US$ 4.6 [INR 300], and was confirmed by presence of below poverty line (BPL) ration card by the family [8].

Visual impairment (VI): This was defined as per definitions suggested by World Health Organization (WHO) [9]. Visual impairment was considered in this study when presenting visual acuity was less than 6/18 in the better eye. It included moderate visual impairment, severe visual impairment and blindness. Moderate visual impairment was defined as presenting visual acuity<6/18 and ≥6/60 in the better eye. Severe visual impairment was defined as presenting visual acuity<6/60 and ≥3/60 in the better eye.

Blindness: was defined as presenting visual acuity<3/60 in the better eye.

Unilateral visual impairment: Presenting visual acuity worse than 6/18 in one eye but better than or equal to 6/18 in other eye. Those with bilateral visual impairment were not considered [10].

Unilateral Blindness: Presenting visual acuity worse than 3/60 in one eye but better than or equal to 6/18 in other eye. Those with bilateral visual impairment were not considered [10]. Uncorrected Refractive Error: When the presenting visual acuity was less than 6/18 but improved to 6/18 or better with refraction.

Cataract: Opacity of the crystalline lens in the pupillary area, as seen with torchlight.

Central Corneal Opacity: Easily visible corneal opacity present over the pupil.

Other causes of visual impairment: all causes other than mentioned above were included in this category.

For ascertaining cause of visual impairment, first the cause was recorded for each eye separately and then for the person. In a possible scenario of two causes for visual impairment present for each eye, one that was more avoidable that is either preventable or treatable, was recorded. For uncorrected refractive error and untreated cataract present in same person, uncorrected refractive error was recorded as principle cause for visual impairment. This is as per suggested methodology of WHO for surveys on blindness and visual impairment [11].

Data management and analysis

Data entry was performed using Microsoft Access based database with in-built consistency and validation checks. Statistical analysis was carried out using Stata 12.0 (Stata Corp., College Station, TX, USA). Data were presented as numbers and percentages. Prevalence estimates were computed and presented along with 95% confidence intervals. These have

been adjusted for cluster design. Multivariate logistic regression analysis was performed for determining associated factors using survey analysis (*svy:logit* command) to account for cluster design and confounding. The results were presented as odds ratios and 95% confidence intervals.

Results

A total of 2025 persons aged ≥50 years were enumerated in 34 study clusters of rural Jhajjar. Out of these 1690 (83.5%) were examined at household level, 146 participants were found to be have presenting visual acuity ≥6/12 in both eyes and 1544 participants were referred for further evaluation due to any of the referral reason- visual acuity<6/12 in any eye, spectacle use or history of cataract surgery. Out of the referred participants, 1429 participants reached to the temporary clinic and were being examined again. Thus, a total of 1575 participants (including 146 with normal presenting visual acuity at the household level) have been included in the present study to estimate the prevalence of visual impairment. The socio-demographic characteristics of the enumerated and examined participants is shown in Table 1. The mean age (SD) of the examined persons was 62.9 (9.7) years, and was similar for both men [63.1 (9.9) years] and women [62.9 (9.5) years]. Out of all the examined persons, 817(52%) were illiterate, 1085 (69%) were engaged in house work and 1156 (73%) were married.

Prevalence of visual impairment and blindness

A total of 386 participants were found to be visually impaired yielding a prevalence of 24.5% (95% CI: 21.1, 26.3) as shown in Table 2. The predominant category was moderate visual impairment as seen in 277 individuals, with a prevalence as 17.6% (95% CI: 14.9, 18.6). The blindness was found in 79 participants with prevalence of 5.0% (95% CI: 3.9, 6.1).

Causes of visual impairment and blindness

On ascertaining causes amongst visually impaired adults, 50% were found to have uncorrected refractive errors and 37% had cataract (Table 3). Cataract was the predominant cause contributing to severe visual impairment (70%) and blindness (57%) respectively. The central corneal opacities resulted in 65% of visual impairment and 19% of blindness. Other causes contributed to 13% of visual impairment and 34% of blindness respectively.

Factors associated with visual impairment and blindness

On multivariable logistic regression analysis (Table 4), visual impairment was found to be associated with increasing age. Adults aged 60-69 years and more than equal to 70 years had four times [aOR 3.7, 95% CI: 2.7, 5.3] and six times [aOR 6.1, 95% CI: 4.3, 8.6] significantly higher odds of visual impairment than adults aged 50-59 years. Women compared to men were found to be positively associated with visual impairment on bivariate analysis, but after adjusting for other factors on multivariable analysis, were found to be negatively associated [aOR 0.7, 95% CI: 0.5, 0.9]. Single adults compared to married adults were found to have two times higher odds of visual impairment [aOR 1.6, 95% CI: 1.1, 2.1]. Education was also found to be significantly associated with visual impairment, increasing level of education was found to be protective. Compared to illiterate adults, the odds of visual impairment were lesser amongst those educated up to primary level [aOR 0.6, 95% CI: 0.5, 0.8], secondary level [aOR 0.3, 95% CI: 0.2,0.5] and senior secondary level [aOR 0.3, 95% CI: 0.2, 0.6].

Similar factors like increasing age, marital status, and educational levels were found to be associated significantly with blindness.

Unilateral Visual Impairment - prevalence, causes and associated factors

Participants with bilateral visual impairment (386) were excluded for this analysis and prevalence of unilateral visual impairment was considered for remaining 1189 participants. A total of 227 participants were identified with unilateral visual impairment, with a prevalence

as 14.4% (95% CI: 12.3, 16.5). The most common cause was uncorrected refractive errors in 173 (76%), cataract in 28 (12%), central corneal opacity in 16 (7%), others in 10 (4%) adults respectively. On multivariate logistic regression analysis (Table 5), the odds of unilateral visual impairment were found to be three times higher in adults aged 60-69 years [aOR 2.6, 95% CI: 1.7,4.0]; and six times higher in adults aged ≥70 years [aOR 5.2, 95% CI: 3.4, 8.1] respectively compared to adults aged 50-59 years. The odds of unilateral visual impairment were found to be 50% lesser in adults educated upto primary level compared to illiterate adults [aOR 0.5, 95% CI: 0.3,0.9].

Discussion

To best of our knowledge, this was the first population level assessment of visual impairment and blindness conducted within district Jhajjar of state Haryana. The prevalence of visual impairment in our study sample was found to be 24.5% (95% CI: 21.1, 26.3). This is almost similar to recent population level estimates from southern states of India. The reported prevalence of visual impairment in adults aged ≥ 50 years in a newly formed southern state of Telengana was 23.5% (95% CI: 22.1, 25.0) [12]. The Andhra Pradesh Rapid Assessment of Visual Impairment study (AP-RAVI) that included both rural and urban clusters, estimated prevalence of VI as 23.1 (95% CI: 21.8, 24.5) [13]. These studies followed almost similar methodology as ours especially in regard to ocular examination. In an urban setting of Delhi within north India, the prevalence of visual impairment was reported slightly lower as 18.5% (95% CI: 16.4, 20.6 [6]. Our study included all rural clusters and it has been reported earlier that the magnitude of visual impairment is higher in rural areas than urban areas. The differences in rural and urban clusters might be ascribed to differences in accessibility and availability of eye care services and personnel. There has not been much progress in reduction of magnitude of visual impairment as the nationwide study (16 districts, predominantly rural) published in year 2008 that estimated visual impairment as 25% [4]. The prevalence estimate for visual impairment reported for other Asian countries is also variable and is reported lower than Indian estimates- Sri Lanka [14], China [15], Bangladesh [16], Malaysia [17], Timor-Leste [18] and Nepal [19]. The prevalence in these studies

differed owing to variations in study location, methods utilized in visual assessment, sample size, access to eye care services and socio-economic variations of the population studied.

In our study, 87% of visual impairment was contributed by two causes- uncorrected refractive errors (50%) followed by cataract (37%). The most common cause for blindness (57%) and severe visual impairment (70%) was cataract. This is consistent with other studies [6,12,13] where 80-90% of visual impairment is attributed to these two causes. Globally, majority of visual impairment is contributed by uncorrected refractive errors followed by cataract [1]. Cataract and uncorrected refractive errors combined contributed to 55% of blindness and 77% of vision impairment in adults aged 50 years and older in 2015 [20]. Also, globally in year 2015, the leading causes of moderate or severe vision impairment in those aged 50 years and older were uncorrected refractive errors (52%) followed by cataract (25%). Uncorrected refractive errors contributed to a larger proportion of vision impairment in South Asia (66%) than in other regions [20].

Increasing age is one the commonest associated factor for visual impairment [21, 22, 23, 24]. In our study, elderly adults aged 70 years and above had the highest odds of visual impairment compared to adults in the fifth decade. There have been variations in association of gender and visual impairment in different studies depending on study location and sample studied. In our study, on multivariate analysis, women were found to have 30% lesser odds for visual impairment than men. Similar finding has been reported from a south Indian study on visual impairment that included marine fishing population as sample [25]. Contrastingly, some studies in Indian settings have reported no association with gender [13] or women to have higher risk for visual impairment [6,4, 26]. We found visual impairment to be associated with single adults compared to married adults, possibly due to lack of support system and access to eye care services. Visual impairment in our study was found to be lower in those who had completed higher schooling levels. Previous studies have reported higher prevalence

of visual impairment among those who were not educated [27,28,29,30] . This could be due to higher visual need, demand and better awareness and accessibility for eye care services by more educated people in our sample as postulated in other study from Indian setting [31].

To represent the complete burden of visual impairment in our study population, we also computed the prevalence of unilateral visual impairment. Our prevalence estimate of 14% was slightly higher than what had been reported earlier in Andhra Pradesh as 11.3% (95% CI: 10.5, 12.1). This study had included adults more than equal to 40 years from both rural and urban clusters [10]. The unilateral visual impairment in our study was found to be associated with age, education and poverty status, consistent with other studies [10,32,33]. It is postulated that socio-economic factors influence the health seeking behaviour of individuals in terms of accessibility and affordability for eye care services. Also, visual impairment can contribute to the individuals' and their families' socioeconomic status [32]. The persons with unilateral visual impairment are also affected by poor quality of life [34,35, 36] and correcting it has immense benefits [37].

This study suffers from some limitations also. Firstly, the cause ascertainment of visual impairment, done by ophthalmic technicians through torch light examination largely focused on anterior segment causes viz uncorrected refractive errors and cataract. The rapid assessment studies performed in this way underestimate posterior segment pathologies as their diagnosis in an undilated pupil is difficult to ascertain. However, this would not affect the prevalence of visual impairment in this population which was the primary objective for this study. Secondly, this study was done in only rural population; thus our results would not be generalizable to urban population. Thirdly, the study would have been further strengthened if we would have estimated false positive and false negative rate of the initial vision screening at household level. However we are reassured that the workers were well trained in recording vision and were cross checked satisfactorily in ten percent of participants.

Our study has programmatic implications. Extrapolating our high prevalence estimates for visual impairment in rural population of 0.7 million size within Jhajjar district, there were 27,034 visually impaired adults above the age group 50 yrs with uncorrected refractive errors and 12,580 visually impaired adults with cataract. These can easily be treated by cataract surgeries and provision of refractive services, including uptake of spectacles through integrated service delivery models for primary and secondary eye care [38]. Recently, the programme in Indian settings has been renamed and included visual impairment, giving due importance to curb the burden related to visual impairment [39].

In conclusion, the prevalence of visual impairment in rural Jhajjar was found to be high as 24% and blindness as 5% in adults aged 50 years and above. The most common causes of visual impairment were uncorrected refractive errors and cataract. The prevalence of unilateral visual impairment was 14%. Provision of spectacles and cataract surgical services are needed to tackle the unfinished agenda of visual impairment in this population.

Contributor ship statement

SM, PV conceived and designed the study with additional inputs from NG, SSS and SKG. SM, PV, NG, SSS supervised the overall conduct and data collection process for the study. MK, RSS managed the dataset and analysed it with additional inputs from SM, PV, SKG. SM wrote the initial draft of the manuscript. All authors contributed to the critique and modification of the manuscript, read and approved the final version.

Competing Interests: None

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Data sharing statement

All unpublished data related to this research project are available with the authors and can be requested by emailing to drsumitaiims@gmail.com

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Table 1. Socio-demographic Characteristics

Variable		Enumerated Adults n=2025 (%)	Examined Adults n=1575 (%)
Age (Years)	50-59	771 (38)	584 (37)
	60-69	745 (37)	584 (37)
	≥70	509 (25)	407 (26)
Gender	Men	973 (48)	678 (43)
	Women	1052 (52)	897 (57)
Marriage	Married	1511 (75)	1156 (73)
	Single (Unmarried/ Widower)	514 (25)	419 (27)
Occupation	Housework	1305 (64)	1085 (69)
	Labour- Agricultural/ Non-Agricultural	326 (16)	218 (14)
	Office/ Skilled work	166 (8)	99 (6)
	Unemployed/ Retired	228 (12)	173 (11)
Education	Illiterate	1017 (50)	817 (52)
	Primary (Upto 5th Class)	272 (13)	221 (14)
	Secondary (Upto 10th Class)	600 (30)	452 (29)
	Senior Secondary and above	136 (7)	85 (5)
Poverty Line (PL)	Above Poverty Line	1668 (82)	1294 (82)
	Below Poverty Line	357 (18)	281 (18)

Table 2. Categories of Visual Impairment

	Presenting Visual Acuity	Number	Percentage	95% Confidence Intervals
Normal	≥6/18	1189	75.5	
Moderate	<6/18 – 6/60	277	17.6	14.9, 18.6

Visual Impairment				
Severe Visual Impairment	<6/60-3/60	30	1.9	0.9, 2.8
Blindness	<3/60	79	5.0	3.9, 6.1

VI: Visual Impairment; PVA- Presenting Visual Acuity

Table 3. Causes of visual impairment

S.No	Cause	Moderate Visual Impairment n (%)	Severe Visual Impairment n (%)	Blindness n (%)
1	Uncorrected Refractive Errors	182 (65.7)	03 (10.0)	07 (8.9)
2	Cataract	77 (27.8)	21 (70.0)	45 (56.9)
3	Central Corneal Opacity	11 (4.0)	03 (10.0)	12 (15.2)
4	Others	07 (2.5)	03 (10.0)	15 (18.9)
	Total	277	30	79

Table 4. Bivariate analysis and Multivariate analysis for Visual Impairment

Variable		Participants n (1575)	Visual impairment (n) %	Unadjusted Odds Ratio (95% CI)	p value	Adjusted Odds Ratio (95% CI)	p value
Age (Years)	50-59	584	46 (08)	1.0		1.0	
	60-69	584	162 (28)	4.5 (3.2, 6.3)	<0.001	3.8 (2.7, 5.3)	<0.001
	≥70	407	178 (44)	9.1 (6.6, 12.6)	<0.001	6.1 (4.3, 8.6)	<0.001
Gender	Men	678	150 (22)	1.0		1.0	
	Women	897	236 (26)	1.3 (1.0, 1.6)	0.10	0.7 (0.5, 0.9)	0.009
Marriage	Married	1156	226 (20)	1.0		1.0	
	Single (Unmarried/ Widower)	419	160 (38)	2.5 (1.9, 3.3)	<0.001	1.6 (1.1, 2.1)	0.007
Education	Illiterate	817	271 (33)	1.0		1.0	
	Primary (Upto 5th Class)	221	46 (21)	0.5 (0.4, 0.7)	<0.001	0.6 (0.5, 0.8)	0.003
	Secondary (Upto 10th Class)	452	59 (13)	0.3 (0.2, 0.4)	<0.001	0.3 (02, 0.5)	<0.001
	Senior Secondary and above	85	10 (12)	0.3 (0.1, 0.5)	<0.001	0.3 (0.2, 0.6)	0.001

Table 5. Bivariate analysis and Multivariate analysis for Unilateral Visual Impairment

Variable		Participants n (1189)*	Unilateral Visual impairment (n) %	Unadjusted Odds Ratio (95% CI)	p value	Adjusted Odds Ratio (95% CI)	p value
Age (Years)	50-59	538	47 (09)	1.0		1.0	
	60-69	422	93 (22)	2.9 (1.9, 4.4)	<0.001	2.6 (1.7, 4.0)	<0.001
	≥70	229	87 (38)	6.4 (4.4, 9.3)	<0.001	5.2 (3.4, 8.1)	<0.001
Gender	Men	528	86 (16)	1.0		1.0	
	Women	661	141 (21)	1.4 (1.0, 1.9)	0.09	1.0 (0.7, 1.5)	0.89
Marriage	Married	930	151 (16)	1.0		1.0	
	Single (Unmarried/ Widower)	259	76 (29)	2.1 (1.5, 3.0)	0.04	1.4 (0.9, 2.1)	0.12
Education	Illiterate	546	139 (26)	1.0		1.0	
	Primary (Upto 5th Class)	175	22 (13)	0.4 (0.3, 0.6)	0.005	0.5 (0.3, 0.9)	0.02
	Secondary (Upto 10th Class)	393	58 (15)	0.5 (0.4, 0.7)	0.06	0.7 (0.5, 1.1)	0.16
	Senior Secondary and above	75	08 (11)	0.3 (0.2, 0.8)	0.08	0.5 (0.2, 1.2)	0.11

*- 386 participants with bilateral visual impairment have been excluded for unilateral visual impairment

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8,9,10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7,8,9,10*
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	6,7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12,13
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	12,13,14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12,13,14

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13,14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence and causes of visual impairment amongst older adults in a rural area of North India- A cross-sectional study

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Prevalence and causes of visual impairment amongst older adults in a rural area of North India- A cross-sectional study

Sumit Malhotra[1], Praveen Vashist[2], Mani Kalaivani[3], Noopur Gupta[4], Suraj Singh Senjam[2], Ramashankar Rath[1], Sanjeev Kumar Gupta[1]

Author Affiliations:

1. Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi
2. Community Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi
3. Department of Biostatistics, All India Institute of Medical Sciences, New Delhi
4. Department of Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi

Corresponding Author:

Dr. Sumit Malhotra,

Associate Professor,

Centre for Community Medicine,

All India Institute of Medical Sciences,

New Delhi-110029,

India

E-mail ID: drsumitaiims@gmail.com

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Abstract (Word Count: 266)

OBJECTIVES

To determine the prevalence, causes and associated factors for visual impairment in rural population of Jhajjar district, Haryana, north India.

METHODS

A community-based, cross-sectional study was conducted in two blocks of Jhajjar district. A total of thirty four villages were selected using Probability Proportionate to Size (PPS) sampling method. Adults aged 50 years and above, were selected using compact segment cluster sampling approach. Presenting visual acuity using LogMAR E chart was measured along with collection of other demographic details as part of the house-to-house survey. Subjective refraction and torch light examination was performed at a clinic site within the village to ascertain visual impairment and its cause. Visual impairment was considered when presenting visual acuity was less than 6/18 in the better eye. Common causes of visual impairment viz uncorrected refractive errors, cataract, central corneal opacity and others were noted by optometrists. Descriptive analysis was undertaken. Multivariate logistic regression analysis was performed for determining associated factors with visual impairment.

RESULTS

Out of 2025 enumerated adults, 1690 (83.5%) were examined at the household level and 1575 (78%) completed all study procedures. The prevalence of visual impairment was found to be 24.5% (95% CI: 21.1, 26.3) and blindness was 5% (95% CI: 3.9, 6.1). The most common causes of visual impairment were uncorrected refractive errors (50%) and cataract (37%). The visual impairment in study participants was found to be associated with age, gender, marital and educational status.

CONCLUSIONS

Visual impairment is still a public health problem in rural population of Jhajjar district, Haryana. Provision of spectacles and cataract surgical services are simple interventions to address this issue.

Strengths and Limitations of this study

- It is a community based study using rapid survey procedures.
- It is first assessment for visual impairment in Jhajjar district, Haryana within north India and generates evidence for programmatic action.
- There might be underestimation of posterior segment pathologies as their diagnosis is difficult to ascertain in an undilated pupil.
- This study is done in rural population, thus results might not be generalizable to urban settings.

Introduction

Eye diseases, vision loss and resulting disability remain a major public health concern[1]. It has been estimated that globally, 253 million people are visually impaired, out of which 36 million are blind and 217 million have moderate to severe visual impairment[2]. Though there has been decline noted in prevalence of blindness over recent times, blindness has actually increased in absolute terms owing to increase in numbers of older people with rise in life expectancy[2]. Much of this global burden is distributed unevenly and some regions have higher burden compared to others. The south Asia (that includes India) region contributes maximum to global blindness and moderate or severe visual impairment burden. It is estimated that south Asia has 12 million blind people and 61 million people with moderate or severe visual impairment[2]. The age standardized prevalence of moderate or severe visual impairment in South Asia is three times higher than high-income regions[2]. Much of the load of blindness (80%) has been attributed to avoidable causes that can be either prevented or corrected easily[1]. The maximum visual impairment is seen in older adult population i.e. after 50 years of age- 86% of those blind and 80% of those with moderate or severe visual impairment are older than 50 years[2]. The global eye health action plan 2014-19, endorsed by sixty-sixth World Health Assembly, charted out broad eye health programmatic components. A vital target was set to achieve reduction in prevalence of avoidable visual impairment by one quarter till year 2019 against baseline values in year 2010. One of the key objectives included under this plan was to undertake epidemiological surveys on visual impairment at regular intervals nationally and sub-nationally, so as to generate evidence about magnitude and causes of visual impairment[3].

According to recent global estimates, India records one of the highest prevalence of visual impairment. The age standardized prevalence of blindness and moderate or severe visual impairment in India is 4% and 17% respectively amongst adults aged 50 and more[2].

The last nation-wide blindness assessment undertaken in India was published way back in the year 2008[4]. Though there has been recent increase in epidemiological research on visual impairment, these studies are largely done in southern part of India. There is need to generate population level evidence on visual impairment in northern states of India for efficient planning of eye care services, where studies in this context are lacking especially from rural parts. Against this background, the current study was done to determine prevalence and causes of visual impairment in older adults in a rural area of north India. We also report here the common associated factors with visual impairment in the study population.

Materials and Methods

This was a community-based cross-sectional survey.

Study Setting

The study was conducted in Jhajjar district of north India. The Jhajjar district is one of the twenty one districts of the state of Haryana, situated at 65 km distance from National Capital Territory of Delhi. The total population of the district was 9,58,405 as per census 2011[5]. The district comprised predominantly rural population (75%) with sex ratio highly skewed towards males (862 females per 1000 males). The study was done in two of the five blocks, namely Bahadurgarh and Jhajjar, selected randomly from all the five blocks. Rural population was only considered within these blocks for purpose of this study as rural areas are reported to have more burden of visual impairment than urban counterparts[4]. A list of villages in these blocks was prepared and villages were arranged according to the increasing size of population. Selection of villages was done based on Probability Proportional to Size (PPS) sampling method giving weightage according to population size. Thirty four villages were selected in these two blocks using this strategy. Each village was considered as a cluster and compact cluster sampling strategy was employed for selection of households within each cluster. Each selected village was broken down to compact segments of 400-600 population. One compact segment was selected randomly using concealed envelopes and all adults in the target age more than or equal to 50 years were enumerated. It was ensured that a minimum of 45-50 participants in the target age group were enumerated in each selected segment for examination. The data was collected during January to May 2014.

Sample Size

We assumed prevalence of visual impairment in adults more than 50 years as 18.5%[6]. This was the most recent estimate available from northern India. With relative precision of 15%,

design effect of 1.5 to account for cluster design and 25% non-response, 1469 participants were required in this current study to meet the objective of determining prevalence of visual impairment.

Ethics statement

The ethics approval for conduct of the study was obtained from Institute Ethics Committee of All India Institute of Medical Sciences (AIIMS), New Delhi. The study procedures conformed to the principles laid out by Declaration of Helsinki. The local consent was taken from the village leaders for participation at the cluster level. Participants were explained about study aspects through participant information sheets designed in local language. Sequentially, written informed consent was obtained from head of household for all participants within the household that were enrolled in this study. All participants detected with visual impairment were referred to the ophthalmic outpatient department at AIIMS, Jhajjar complex.

Examination teams

Two study teams were engaged in data collection and examination. Each team comprised of one optometrist, Social Worker (SW) and Health Assistant (HA). The personnel selected for this epidemiological research work were rendering primary eye care in the vision clinics for more than two years including vision examination by LogMAR charts. The optometrists were degree/ diploma holders in optometry. The teams were sensitized and trained in all procedures related to data collection and examination. A three day training including field practice session was conducted for all study personnel by epidemiologist and ophthalmologist and included components of enumeration of participants and eliciting relevant details as per data collection instruments, vision examination and detailed work up for visually impaired

persons for ascertaining the cause. The inter-observer correlation (Kappa) coefficient was found 0.7-0.8 for same level of observers.

At first level, house-to-house visit was done by social worker and health assistant. The social worker took written informed consent from head of households and explained all study procedures to all study participants; built adequate rapport and coordinated referral of participants for detailed eye work up by optometrists. Demographic details, ocular disease history (past cataract surgeries and spectacle use) and, presenting distance visual acuity was measured for eligible study participants by the health assistant with the help of social worker. The presenting visual acuity was measured using screening chart corresponding to five "E" 6/12 optotypes. Correct identification of four letters out of five was considered as pass criteria. The visual acuity measurement was done at distance of four meters, outdoors and in shade on bright and sunny days. Adequate care was given to avoid reflections and glare on the vision placard. Presenting visual acuity was considered as vision with spectacles if using spectacles for distance vision. All participants with presenting visual acuity<6/12 in either eye, adults using spectacles and those with previous cataract surgery were referred to a temporary makeshift clinic within a village building where optometrists performed detailed eye assessment. The optometrists repeated the visual acuity assessment using retro illuminated conventional logMAR tumbling E charts and performed the torch light examination, and non-cycloplegic refraction. Lens was assessed using torch light. A pupil that clearly appeared grey or white when examined with oblique light was noted as obvious lens opacity and cataract[7]. Common causes of visual impairment viz uncorrected refractive errors, cataract, central corneal opacity, and 'others' were documented by optometrists.

Quality assurance and standardization of all study procedures and equipment was done throughout the conduct of this study to minimize errors during the data collection. Pilot testing of all procedures was done in one of the villages that were not part of the study

clusters. The study investigating team including the epidemiologist and ophthalmologist, supervised all data collection and examination procedures. The epidemiologist was responsible for finalization of study compact segment within each cluster village and finalization of central location for clinical examination to maximize access for all participants. Visitors to households and those people outside the selected compact segment were not included in the study procedures to minimize bias. Random checks to households were done to examine the information collected from household members and their visual status. The ophthalmologist also examined randomly eyes of visually impaired persons to cross check findings of optometrists. Ten percent of all participants' forms and recorded vision findings were rechecked within the study cluster by the epidemiologist and ophthalmologist, including those that were detected with normal visual acuity at the initial time of screening at household level.

Operational definitions: Various terms used were defined as below:

Older adults: Participants≥ 50 years of age[2].

Below poverty line: was considered for an adult when monthly income was less than US$ 4.6 [INR 300], and was confirmed by presence of below poverty line (BPL) ration card by the family[8].

Visual impairment (VI): This was defined as per definitions suggested by World Health Organization (WHO)[9]. Visual impairment was considered in this study when presenting visual acuity was less than 6/18 in the better eye. It included moderate visual impairment, severe visual impairment and blindness. Moderate visual impairment was defined as presenting visual acuity<6/18 and ≥6/60 in the better eye. Severe visual impairment was defined as presenting visual acuity<6/60 and ≥3/60 in the better eye.

Blindness: was defined as presenting visual acuity<3/60 in the better eye.

Unilateral visual impairment: Presenting visual acuity worse than 6/18 in one eye but better than or equal to 6/18 in other eye. Those with bilateral visual impairment were not considered[10].

Unilateral Blindness: Presenting visual acuity worse than 3/60 in one eye but better than or equal to 6/18 in other eye. Those with bilateral visual impairment were not considered[10].
Uncorrected Refractive Error: When the presenting visual acuity was less than 6/18 but improved to 6/18 or better with refraction.

Cataract: Opacity of the crystalline lens in the pupillary area, as seen with torchlight.

Central Corneal Opacity: Easily visible corneal opacity present over the pupil.

Other causes of visual impairment: all causes other than mentioned above were included in this category.

For ascertaining cause of visual impairment, first the cause was recorded for each eye separately and then for the person. In a possible scenario of two causes for visual impairment present for each eye, one that was more avoidable that is either preventable or treatable, was recorded. For uncorrected refractive error and untreated cataract present in same person, uncorrected refractive error was recorded as principle cause for visual impairment. This is as per suggested methodology of WHO for surveys on blindness and visual impairment[11].

Data management and analysis

Data entry was performed using Microsoft Access based database with in-built consistency and validation checks. Statistical analysis was carried out using Stata 12.0 (Stata Corp., College Station, TX, USA). Data were presented as numbers and percentages. Prevalence estimates were computed and presented along with 95% confidence intervals. These have been adjusted for cluster design. Multivariate logistic regression analysis was performed for

determining associated factors using survey analysis (*svy:logit* command) to account for cluster design and confounding. The results were presented as odds ratios and 95% confidence intervals.

Results

A total of 2025 persons aged ≥50 years were enumerated in 34 study clusters of rural Jhajjar. Out of these 1690 (83.5%) were examined at household level, 146 participants were found to be have presenting visual acuity ≥6/12 in both eyes and 1544 participants were referred for further evaluation due to any of the referral reason- visual acuity<6/12 in any eye, spectacle use or history of cataract surgery. Out of the referred participants, 1429 participants reached to the temporary clinic and were being examined again. Thus, a total of 1575 participants (including 146 with normal presenting visual acuity at the household level) have been included in the present study to estimate the prevalence of visual impairment. The socio-demographic characteristics of the enumerated and examined participants are shown in Table 1. The mean age(SD) of the examined persons was 62.9(9.7) years, and was similar for both men [63.1(9.9)years] and women [62.9(9.5)years]. Out of all the examined persons, 817(52%) were illiterate, 1085(69%) were engaged in house work and 1156(73%) were married.

Prevalence of visual impairment and blindness

A total of 386 participants were found to be visually impaired yielding a prevalence of 24.5% (95% CI: 21.1,26.3) as shown in Table 2. The predominant category was moderate visual impairment as seen in 277 individuals, with prevalence as 17.6%(95% CI: 14.9,18.6). The blindness was found in 79 participants with prevalence of 5.0%(95% CI: 3.9, 6.1).

Causes of visual impairment and blindness

On ascertaining causes amongst visually impaired adults, 50% were found to have uncorrected refractive errors and 37% had cataract(Table 3). Cataract was the predominant cause contributing to severe visual impairment(70%) and blindness(57%) respectively. The

central corneal opacities resulted in 65% of visual impairment and 19% of blindness. Other causes contributed to 13% of visual impairment and 34% of blindness respectively.

Factors associated with visual impairment and blindness

On multivariable logistic regression analysis(Table 4), visual impairment was found to be associated with increasing age. Adults aged 60-69 years and more than equal to 70 years had four times [aOR3.7, 95% CI: 2.7,5.3] and six times [aOR6.1, 95% CI: 4.3,8.6] significantly higher odds of visual impairment than adults aged 50-59 years. Women compared to men were found to be positively associated with visual impairment on bivariate analysis, but after adjusting for other factors on multivariable analysis, were found to be negatively associated [aOR0.7, 95% CI: 0.5,0.9]. Single adults compared to married adults were found to have two times higher odds of visual impairment [aOR1.6, 95% CI: 1.1,2.1]. Education was also found to be significantly associated with visual impairment; increasing level of education was found to be protective. Compared to illiterate adults, the odds of visual impairment were lesser amongst those educated up to primary level [aOR0.6, 95% CI: 0.5,0.8], secondary level [aOR0.3, 95% CI: 0.2,0.5] and senior secondary level [aOR0.3, 95% CI: 0.2,0.6].

Similar factors like increasing age, marital status, and educational levels were found to be associated significantly with blindness.

Unilateral Visual Impairment - prevalence, causes and associated factors

Participants with bilateral visual impairment(386)were excluded for this analysis and prevalence of unilateral visual impairment was considered for remaining 1189 participants. A total of 227 participants were identified with unilateral visual impairment, with prevalence as 14.4%(95% CI: 12.3,16.5). The most common cause was uncorrected refractive errors in 173 (76%), cataract in 28(12%), central corneal opacity in 16(7%), others in 10(4%) adults respectively. On multivariate logistic regression analysis (Table 5), the odds of unilateral

visual impairment were found to be three times higher in adults aged 60-69 years [aOR2.6, 95% CI: 1.7,4.0]; and six times higher in adults aged ≥70 years [aOR5.2, 95% CI: 3.4,8.1] respectively compared to adults aged 50-59 years. The odds of unilateral visual impairment were found to be 50% lesser in adults educated upto primary level compared to illiterate adults [aOR0.5, 95% CI: 0.3,0.9].

Discussion

To best of our knowledge, this was the first population level assessment of visual impairment and blindness conducted within district Jhajjar of state Haryana. The prevalence of visual impairment in our study sample was found to be 24.5%(95% CI: 21.1,26.3). This is almost similar to recent population level estimates from southern states of India. The reported prevalence of visual impairment in adults aged ≥ 50 years in a newly formed southern state of Telengana was 23.5%(95% CI: 22.1,25.0)[12]. The Andhra Pradesh Rapid Assessment of Visual Impairment study (AP-RAVI) that included both rural and urban clusters, estimated prevalence of VI as 23.1%(95% CI: 21.8,24.5)[13]. These studies followed almost similar methodology as ours especially in regard to ocular examination. In an urban setting of Delhi within north India, the prevalence of visual impairment was reported slightly lower as 18.5% (95% CI: 16.4,20.6)[6]. Our study included all rural clusters and it has been reported earlier that the magnitude of visual impairment is higher in rural areas than urban areas. The differences in rural and urban clusters might be ascribed to differences in accessibility and availability of eye care services and personnel. There has not been much progress in reduction of magnitude of visual impairment as the nationwide study (16 districts, predominantly rural) published in year 2008 that estimated visual impairment as 25%[4]. The prevalence estimate for visual impairment reported for other Asian countries is also variable and is reported lower than Indian estimates- Sri Lanka 6%[14], China 13%[15], Bangladesh 10%[16], Malaysia 3%[17], Indonesia 8%[18] and Nepal 19%[19]. The prevalence in these studies differed owing to variations in study location, methods utilized in visual assessment, sample size, access to eye care services and socio-economic variations of the population studied.

In our study, 87% of visual impairment was contributed by two causes- uncorrected refractive errors (50%) followed by cataract (37%). The most common cause for blindness

(57%) and severe visual impairment (70%) was cataract. This is consistent with other studies [6,12,13] where 80-90% of visual impairment is attributed to these two causes. Globally, majority of visual impairment is contributed by uncorrected refractive errors followed by cataract[1]. Cataract and uncorrected refractive errors combined contributed to 55% of blindness and 77% of vision impairment in adults aged 50 years and older in 2015[20]. Also, globally in year 2015, the leading causes of moderate or severe vision impairment in those aged 50 years and older were uncorrected refractive errors (52%) followed by cataract (25%). Uncorrected refractive errors contributed to a larger proportion of vision impairment in South Asia (66%) than in other regions[20].

Increasing age is one the commonest associated factor for visual impairment[16,21,22,23]. In our study, elderly adults aged 70 years and above had the highest odds of visual impairment compared to adults in the fifth decade. There have been variations in association of gender and visual impairment in different studies depending on study location and sample studied. In our study, on multivariate analysis, women were found to have 30% lesser odds for visual impairment than men. Similar finding has been reported from a south Indian study on visual impairment that included marine fishing population as sample[24]. Contrastingly, some studies in Indian settings have reported no association with gender [13] or women to have higher risk for visual impairment[4,6,25]. We found visual impairment to be associated with single adults compared to married adults, possibly due to lack of support system and access to eye care services. Visual impairment in our study was found to be lower in those who had completed higher schooling levels. Previous studies have reported higher prevalence of visual impairment among those who were not educated [26,27,28,29] . This could be due to higher visual need, demand and better awareness and accessibility for eye care services by more educated people in our sample as postulated in other study from Indian setting[30].

To represent the complete burden of visual impairment in our study population, we also computed the prevalence of unilateral visual impairment. Our prevalence estimate of 14% was slightly higher than what had been reported earlier in Andhra Pradesh as 11.3% (95% CI: 10.5,12.1). This study had included adults more than equal to 40 years from both rural and urban clusters[10]. The unilateral visual impairment in our study was found to be associated with age, education and poverty status, consistent with other studies[10,31,32]. It is postulated that socio-economic factors influence the health seeking behaviour of individuals in terms of accessibility and affordability for eye care services. Also, visual impairment can contribute to the individuals' and their families' socioeconomic status[31]. The persons with unilateral visual impairment are also affected by poor quality of life[33,34,35] and correcting it has immense benefits[36].

This study suffers from some limitations also. Firstly, the cause ascertainment of visual impairment, done by optometrists through torch light examination largely focused on anterior segment causes viz uncorrected refractive errors and cataract. The rapid assessment studies performed in this way underestimate posterior segment pathologies as their diagnosis in an undilated pupil is difficult to ascertain. However, this would not affect the prevalence of visual impairment in this population which was the primary objective for this study. Secondly, the reliability of the method for detection of uncorrected refractive errors, as adopted in this rapid assessment study, has not been ascertained especially in community settings. Again, this would not affect our overall prevalence of visual impairment. Thirdly, this study was done in only rural population; thus our results would not be generalizable to urban population. Fourthly, the study would have been further strengthened if we would have estimated false positive and false negative rate of the initial vision screening at household level. However we are reassured that the workers were well trained in recording vision and were cross checked satisfactorily in ten percent of participants.

Our study has programmatic implications. Extrapolating our high prevalence estimates for visual impairment in rural population of 0.7 million size within Jhajjar district, there were 27,034 visually impaired adults above the age group 50 yrs with uncorrected refractive errors and 12,580 visually impaired adults with cataract. These can easily be treated by cataract surgeries and provision of refractive services, including uptake of spectacles through integrated service delivery models for primary and secondary eye care[37]. Recently, the programme in Indian settings has been renamed and included visual impairment, giving due importance to curb the burden related to visual impairment[38].

In conclusion, the prevalence of visual impairment in rural Jhajjar was found to be high as 24% and blindness as 5% in adults aged 50 years and above. The most common causes of visual impairment were uncorrected refractive errors and cataract. The prevalence of unilateral visual impairment was 14%. Provision of spectacles and cataract surgical services are needed to tackle the unfinished agenda of visual impairment in this population.

Contributor ship statement

SM, PV conceived and designed the study with additional inputs from NG, SSS and SKG. SM, PV, NG, SSS supervised the overall conduct and data collection process for the study. MK, RSR managed the dataset and analysed it with additional inputs from SM, PV, SKG. SM wrote the initial draft of the manuscript. All authors contributed to the critique and modification of the manuscript, read and approved the final version.

Competing Interests: None

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Data sharing statement

All unpublished data related to this research project are available with the authors and can be requested by emailing to drsumitaiims@gmail.com

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Table 1. Socio-demographic Characteristics

Variable		Enumerated Adults n=2025 (%)	Examined Adults n=1575 (%)
Age (Years)	50-59	771 (38)	584 (37)
	60-69	745 (37)	584 (37)
	≥70	509 (25)	407 (26)
Gender	Men	973 (48)	678 (43)
	Women	1052 (52)	897 (57)
Marriage	Married	1511 (75)	1156 (73)
	Single (Unmarried/ Widower)	514 (25)	419 (27)
Occupation	Housework	1305 (64)	1085 (69)
	Labour- Agricultural/ Non-Agricultural	326 (16)	218 (14)
	Office/ Skilled work	166 (8)	99 (6)
	Unemployed/ Retired	228 (12)	173 (11)
Education	Illiterate	1017 (50)	817 (52)
	Primary (Upto 5th Class)	272 (13)	221 (14)
	Secondary (Upto 10th Class)	600 (30)	452 (29)
	Senior Secondary and above	136 (7)	85 (5)
Poverty Line (PL)	Above Poverty Line	1668 (82)	1294 (82)
	Below Poverty Line	357 (18)	281 (18)

Table 2. Categories of Visual Impairment

	Presenting Visual Acuity	Number	Percentage	95% Confidence Intervals
Normal	≥6/18	1189	75.5	
Moderate Visual Impairment	<6/18 – 6/60	277	17.6	14.9, 18.6
Severe Visual Impairment	<6/60-3/60	30	1.9	0.9, 2.8
Blindness	<3/60	79	5.0	3.9, 6.1

VI: Visual Impairment; PVA- Presenting Visual Acuity

Table 3. Causes of visual impairment

S.No	Cause	Moderate Visual Impairment n (%)	Severe Visual Impairment n (%)	Blindness n (%)	Total n (%)
1	Uncorrected Refractive Errors	182 (65.7)	03 (10.0)	07 (8.9)	192 (49.7)
2	Cataract	77 (27.8)	21 (70.0)	45 (56.9)	143 (37.0)
3	Central Corneal Opacity	11 (4.0)	03 (10.0)	12 (15.2)	26 (6.7)
4	Others	07 (2.5)	03 (10.0)	15 (18.9)	25 (6.5)
	Total	277	30	79	386

Table 4. Bivariate analysis and Multivariate analysis for Visual Impairment

Variable		Participants n (1575)	Visual impairment (n) %	Unadjusted Odds Ratio (95% CI)	p value	Adjusted Odds Ratio (95% CI)	p value
Age (Years)	50-59	584	46 (08)	1.0		1.0	
	60-69	584	162 (28)	4.5 (3.2, 6.3)	<0.001	3.8 (2.7, 5.3)	<0.001
	≥70	407	178 (44)	9.1 (6.6, 12.6)	<0.001	6.1 (4.3, 8.6)	<0.001
Gender	Men	678	150 (22)	1.0		1.0	
	Women	897	236 (26)	1.3 (1.0, 1.6)	0.10	0.7 (0.5, 0.9)	0.009
Marriage	Married	1156	226 (20)	1.0		1.0	
	Single (Unmarried/ Widower)	419	160 (38)	2.5 (1.9, 3.3)	<0.001	1.6 (1.1, 2.1)	0.007
Education	Illiterate	817	271 (33)	1.0		1.0	
	Primary (Upto 5th Class)	221	46 (21)	0.5 (0.4, 0.7)	<0.001	0.6 (0.5, 0.8)	0.003
	Secondary (Upto 10th Class)	452	59 (13)	0.3 (0.2, 0.4)	<0.001	0.3 (02, 0.5)	<0.001
	Senior Secondary and above	85	10 (12)	0.3 (0.1, 0.5)	<0.001	0.3 (0.2, 0.6)	0.001

Table 5. Bivariate analysis and Multivariate analysis for Unilateral Visual Impairment

Variable		Participants n (1189)*	Unilateral Visual impairment (n) %	Unadjusted Odds Ratio (95% CI)	p value	Adjusted Odds Ratio (95% CI)	p value
Age (Years)	50-59	538	47 (09)	1.0		1.0	
	60-69	422	93 (22)	2.9 (1.9, 4.4)	<0.001	2.6 (1.7, 4.0)	<0.001
	≥70	229	87 (38)	6.4 (4.4, 9.3)	<0.001	5.2 (3.4, 8.1)	<0.001
Gender	Men	528	86 (16)	1.0		1.0	
	Women	661	141 (21)	1.4 (1.0, 1.9)	0.09	1.0 (0.7, 1.5)	0.89
Marriage	Married	930	151 (16)	1.0		1.0	
	Single (Unmarried/ Widower)	259	76 (29)	2.1 (1.5, 3.0)	0.04	1.4 (0.9, 2.1)	0.12
Education	Illiterate	546	139 (26)	1.0		1.0	
	Primary (Upto 5th Class)	175	22 (13)	0.4 (0.3, 0.6)	0.005	0.5 (0.3, 0.9)	0.02
	Secondary (Upto 10th Class)	393	58 (15)	0.5 (0.4, 0.7)	0.06	0.7 (0.5, 1.1)	0.16
	Senior Secondary and above	75	08 (11)	0.3 (0.2, 0.8)	0.08	0.5 (0.2, 1.2)	0.11

*- 386 participants with bilateral visual impairment have been excluded for unilateral visual impairment

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8,9,10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7,8,9,10*
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	6,7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12,13
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	12,13,14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12,13,14

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13,14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.