Risk Factors for Uncorrected Refractive Error: Persian Cohort Eye Study - Rafsanjan Center

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Abstract

Purpose: To determine the prevalence of visually significant uncorrected refractive error (URE) in Rafsanjan and investigate the related factors. URE is the leading cause of visual impairment (VI) which causes the second-highest number of years lived with disability. The URE is a preventable health problem.

Methods: In this cross-sectional study participants from Rafsanjan who were 35–70 years were enrolled between 2014 and 2020. Demographic and clinical characteristics data were gathered, and eye examination was performed. Visually significant URE was defined as present if habitual visual acuity was (HVA; visual acuity with present optical correction) >0.3 logMAR in the best eye and the visual acuity of that eye showed >0.2 logMAR improvement after the best correction. Logistic regression was used to determine the association between predicting variables (age, sex, wealth, education, employment, diabetes, cataract, and refractive error characteristics) and outcome (URE).

Results: Among the 6991 participants of Rafsanjan subcohort of the Persian Eye Cohort, 311 (4.4%) had a visually significant URE. Diabetes was significantly more prevalent in the participants with visually significant URE, at 18.7% versus 13.1% in patients without significant URE ($P = 0.004$). In the final model, each year of increase in age was associated with 3% higher URE (95% confidence interval [CI]: 1.01–1.05). In comparison to low hyperopia, participants with low myopia had 5.17 times more odds of visually significant URE (95% CI: 3.38–7.93). However, antimetropia decreased the risk of visually significant URE (95% CI: 0.02–0.37).

Conclusion: Policymakers should pay special attention to elderly patients with myopia to effectively reduce the prevalence of visually significant URE.

Keywords: Refractive error, Uncorrected refractive error, Visual impairment

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Introduction

Uncorrected refractive error (URE) is the leading cause of visual impairment (VI) which causes the second-highest number of years lived with disability.[1,2] Among total cases with VI, 128 million were attributed to URE in 2020.[2] The universal disability-adjusted life year index for URE has increased by 43.8% between 1990 and 2013.[3] VI could lead to social isolation, economical stress, and reduction in job opportunities and education.[4] Therefore, the World Health Organization dedicated the VISION 2020, a global action plan for universal eye health, to alleviate avoidable VI such as URE.[5] The global cost of URE has been estimated ten times more than what is needed to resolve this issue.[6,7]

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URE is a preventable health problem with a significant impact on the economy and human quality of life.[8] Several population-based studies have demonstrated the extent of URE as a public health problem.[9-12] The prevalence of URE has been reported from 1.13% to 57% in different countries. Several definitions have been used in the literature for reporting the URE. Studies have defined URE as a habitual visual acuity (HVA; visual acuity with present optical correction) was >0.3 logMAR in the best eye with the visual acuity of that eye showing >0.2 logMAR improvement after the best correction.[13,14]

Studies reported an association between increasing age and URE frequency.[15-17] While, female patients were more susceptible to URE in some studies,[15,18] others have reported the opposite.[19-21] Lower education, lack of insurance, and low income have also been related to URE.[17,18,21] Type of refractive error and diabetes are among the diseases that have been associated with URE.[13,15,20,22] A more precise understanding of the distributive prevalence of and associated factors with URE is needed to design effective policies for prevention. In this study, we aimed to determine the prevalence of visually significant URE in Rafsanjan and investigate the related factors.

Methods

This cross-sectional study is based on the Persian Eye Cohort, a collaboration of 6 centers in Iran which is a branch of the Persian Cohort study.[23] The complete protocol of the whole study has been published previously and the protocol of the eye branch of the Persian cohort is under publication.[23] In this study, participants enrolled in one of the centers, Rafsanjan,[24] from 2014 to 2020 are described. Residents of Rafsanjan who were 35–70-year-old and lived in the area that was covered by 5 health centers for at least 1 year were invited up to three times to participate in the Persian Eye Cohort registry. Health centers included three urban health centers, and one rural health center. Participants were excluded if they were unable to communicate with the recruiter, or coming to the center, or not responding to the three invitations. Informed consent was obtained from the study participants, and an optometrist completed a questionnaire about age (years), sex (classified as male and female), education (years), employment (classified as unemployed, employed, retired, and homemaker), wealth index [based on multiple correspondence analysis of access to a freezer, access to a washing machine, access to a dishwasher, access to a computer, internet access, access to a motorcycle, access to a car (no access, access to a car with a price of <50 million Tomans, and access to a car with price of >50 million Tomans), access to a vacuum cleaner, color TV set (no color TV or regular color TV vs. Plasma color TV), mobile phone, PC or laptop, international trips in a lifetime (never, just pilgrimage, both pilgrimage or nonpilgrimage trips)], history of diabetes and duration of disease (year), history of cataract, strabismus, amblyopia treatment, and eye surgeries.[23,25]

Thereafter an optometrist determined habitual (visual acuity with present optical correction) and best-corrected visual acuity (BCVA) and blindness based on the 11th international classification of disease (icd.who.int). Visual acuity impairment was defined in the better eye and classified as mild as 0.3≤HVA<0.5 logMAR, moderate as 0.5≤HVA<1 logMAR, and severe as 1≤HVA logMAR. Blindness was defines as HVA less or equal to 1.3 logMAR.

Present glass characteristics and objective noncycloplegic refraction was measured with an autorefractometer and manually with a retinoscope. Subjective refraction was performed according to the study protocol.[26]

Refractive errors were defined based on spheric equivalent (SE; defined as sphere + half cylinder) as emmetropia with −1≤SE≤1 diopter, low hyperopia with 1<SE<3 diopter, moderate to high hyperopia with 3 diopters ≤SE, low myopia with −3<SE<−1 diopter, high myopia with SE≤−3 diopters.[27] Antimetropia was defined as positive SE in one eye and negative SE in the other eye. Anisometropia was defined as more than one diopter difference between the SE of the eyes. Enantiomorphism was defined as the astigmatic axis of the eyes showing a mirror image of each other based on the difference between the eyes' axis. This difference for enantiomorphism was classified as exact as 0°, first-class as 1°–5°, second class as 6°–10°, and third class as 11°–15°. Axis was classified as with the rule (0°–10° and 170°–180°), against the rule (80°–110°), and oblique.

The participants that fulfilled certain criteria were visited by a trained ophthalmologist who conducted detailed eye examinations. In this step, cataract was classified as present and absent, and retinal detachment was classified as present and absent.

Visually significant URE was defined as HVA >0.3 logMAR in the best eye in which the visual acuity of that eye showed >0.2 logMAR improvement after the best correction. We analyzed participants which had HVA >0.3 logMAR or had HVA <0.3 logMAR where the HVA was less than the BCVA.

We adhered to the guidelines of the Declaration of Helsinki and the Ethics Committee of the Tehran University of Medical Sciences approved this study (IR.TUMS.SPH.REC.1399.066).

Statistical analysis

Continuous variables are described as mean ± standard deviation or median ± interquartile range as appropriate. Categorical variables are shown as frequencies. Independent sample *t*-test was used for comparing means. Pearson Chi-square and Fisher's exact test (if needed) were used for comparing categorical variables. To investigate the independent effect of demographic and clinical variables on the presence of visually significant URE, we entered all univariable analyses with a $P < 0.05$ that were congruent with prior evidence into the conditional enter-multivariable logistic regression model. We performed all statistical analyses using the Stata 16 edition for Windows (StataCorp. 2019. College Station, USA). A $P < 0.05$ was considered significant in all instances.

Results

In the Rafsanjan subcohort of the Persian Eye Study, 8688 participants have been examined. From this population, we analyzed 6991 participants which had HVA >0.3 logMAR or had HVA <0.3 logMAR where HVA was less than their BCVA. Table 1 shows demographic characteristics and the past medical history of participants.

The mean age was 49.25 ± 9.25 (range, 35–70) with 3712 (53.1%) of participants being females. On average, the study population had 8.85 ± 5 (range, 0–26) years of education, and 3389 (48.6%) of them were retired. With the best correction, percentage of patients with visual acuity < 0.3 logMAR increased from 6617 of 6991 (94.7%) to 4140 of 4184 (99%). Diabetes prevalence was 13.3% with 8.12 years of duration on average. History of Strabismus was seen among 61 (0.7%) of the participants. Thirty-one (0.4%) of them had a history of amblyopia, and 904 (10.4%) of the population had eye surgery including cataract surgery, refractive error surgery, laser therapy for diabetic retinopathy, retinal detachment surgery, and glaucoma surgery. Table 2 demonstrates the eye examination of participants. Emmetropia prevalence was 78.1%, and 880 participants had astigmatism >1.5 diopters.

Of 6991 participants, 311 (4.4%) had a visually significant URE. Age was significantly higher among the participants with visually significant URE compared with visually insignificant URE (odds ratio [OR]: 1.02, 95% confidence interval [CI]: 1.01–1.05, $P < 0.001$). There were no differences between sex, wealth index, education, and employment among participants with or without URE. Diabetes was significantly more prevalent in the participants with visually significant URE, with 18.7% versus 13.1% in patients with without significant URE ($P = 0.004$). However, the diabetes duration was not different. In the eye examination, cataract was seen in 6.1% of participants with visually significant URE, but it was only present in 2.3% of participants without visually significant URE ($P < 0.001$).

Moderate-to-severe myopia and hyperopia were more prevalent among the participants with visually significant URE (OR: 85.91, 95% CI: 46.03–160.34; OR: 45.78, 95% CI: 18.18–120.35, respectively). Anisometropia was seen in 18% of participants with visually significant URE, but it was only present in 3.5% of participants without visually significant URE ($P < 0.001$). On the other hand, antimetropia was more prevalent in the participants without visually significant URE (OR: 0.26, 95% CI: 0.14-0.47, $P = 0.004$).

Astigmatism >1.5 diopters was more prevalent among the participants with visually significant URE. In the population with astigmatism >1.5 diopters, with the rule type was less seen in those participants with visually significant URE compared with the percentage in the visually insignificant URE ($P = 0.043$). Moreover, myopic astigmatism was also more prevalent among the participants with visually significant URE compared to those without significant URE ($P < 0.001$).

To calculate the OR, variables with $P < 0.05$ in the preliminary analysis were entered into logistic regression: Age, diabetes, high astigmatism, refractive error, anisometropia, antimetropia, with the rule astigmatism, and cataract in physical examination. Among different classifications of astigmatism, oblique, with the rule and against the role were selected for further analysis in which only with the rule was negatively associated with visually significant URE. In the cataract investigation,

Table 1: Demographic characteristics and past medical history of participants

Variable	*n*	Total	Visually significant URE		*P*
			Yes (*n*=311)	No	
Age, mean±SD (range)	6990	49.25±9.25 (35–70)	51.01±9.55	49.16±9.23	<0.001*[a]
Sex, *n* (%)					
Female	6991	3712 (53.1)	162 (52.1)	3550 (53.1)	0.716[b]
Male		3279 (46.9)	149 (47.9)	3130 (4686)	
Wealth index, mean±SD (range)	6982	0.01±0.95 (−3.98–2.59)	−0.081±0.95	0.031±0.95	0.689[a]
Education, mean±SD (range)	6990	8.85±4.93 (0–26)	9.02±5.4	8.84±4.9	0.529[a]
Employment, *n* (%)					
Unemployed	6973	109 (1.6)	9 (2.9)	100 (1.5)	0.211[b]
Housewife		2764 (39.6)	116 (37.4)	2648 (39.7)	
Retired		3389 (48.6)	150 (48.4)	3239 (48.6)	
Employed		711 (10.2)	35 (11.3)	676 (10.2)	
Diabetes, *n* (%)					
No	6976	6049 (86.7)	252 (81.3)	5797 (86.9)	0.004*[b]
Yes		927 (13.3)	58 (18.7)	869 (13.1)	
Diabetes duration, mean±SD (range)	921	8.12±6.19 (1–40)	9.29±7.82	8.04±6.05	0.135[a]
Cataract, *n* (%)					
No	6991	6475 (92.6)	278 (89.4)	6524 (92.8)	<0.001*[b]
Present in examination		175 (2.5)	19 (6.1)	156 (2.3)	
Positive history		341 (4.9)	14 (4.5)	327 (4.9)	

*Statistically significant, [a]Independent sample *t*-test, [b]Pearson Chi-square. SD: Standard deviation, URE: Uncorrected refractive error

Table 2: Refractive variables of participants

Variables	*n*	Total	Visually significant URE		*P*
			Yes (*n*=311)	No	
Visual acuity, mean±SD (range)					
HVA	8661	0.18±0.31 (0–3)	0.74±0.42	0.07±0.001	<0.001*[a]
BCVA	5016	0.02±0.09 (0–3)	0.07±0.006	0.01±0.001	<0.001*[a]
Severity of VI (based on HVA), *n* (%)					
No impairment	6991	6617 (94.7)	0	6617 (99.0)	<0.001*[b]
Mild		133 (1.9)	101 (32.5)	32 (0.5)	
Moderate		210 (3.0)	184 (59.2)	26 (0.4)	
Severe		31 (0.4)	26 (8.3)	5 (0.1)	
Severity of VI (based on BCVA), *n* (%)					
No impairment	4184	4140 (99.0)	300 (96.5)	3840 (99.2)	<0.001*[c]
Mild		23 (0.6)	9 (2.9)	14 (0.3)	
Moderate		18 (0.4)	2 (0.6)	16 (0.4)	
Severe		3 (0.1)	0	3 (0.1)	
Blindness, *n* (%)	6991	31 (0.4)	26 (8.4)	5 (0.1)	<0.001*[c]
Distance objective refraction, mean (SD)					
Sphere (D)	8654	0.08±1.43 (−15–12)	−1.1±0.16	0.3±0.009	<0.001*[a]
Cylinder (D)	8654	−0.87±0.79 (−7.5–0)	−1.4±0.06	−0.7±0.007	<0.001*[a]
Axis	8188	92.5±45.8 (0–179)	93.1±2.7	92.9±0.6	0.971[a]
Refractive error, *n* (%)					
Emmetropia	6990	5456 (78.1)	30 (9.7)	5426 (81.1)	<0.001*[b]
Low myopia		811 (11.6)	147 (47.3)	664 (9.8)	
Moderate-to-high myopia		103 (1.5)	85 (27.3)	18 (0.3)	
Low hyperopia		595 (8.5)	31 (9.9)	564 (8.4)	
Moderate to high hyperopia		25 (0.3)	18 (5.8)	25 (0.4)	
Anisometropia, n (%)					
No	6964	6675 (95.9)	255 (82.0)	6420 (96.5)	<0.001*[b]
Yes		289 (4.1)	65 (18.0)	233 (3.5)	
Antimetropia, *n* (%)					
No	6964	6128 (88.0)	300 (96.5)	5828 (87.6)	<0.001*[,b]
Yes		836 (12.0)	11 (3.5)	825 (12.4)	
High astigmatism (≥1.5 D), *n* (%)					
No	6990	6110	252 (81.3)	5797 (86.9)	0.004*[b]
Yes		880	58 (18.7)	869 (13.1)	
Enantiomorphism, *n* (%)					
No	880	697 (79.2)	105 (83.3)	592 (78.5)	0.081[c]
Exact		37 (4.2)	8 (6.3)	29 (3.9)	
First class		50 (5.7)	6 (4.8)	44 (5.8)	
Second class		68 (7.7)	4 (3.2)	64 (8.5)	
Third class		28 (3.2)	3 (2.4)	25 (3.3)	
Astigmatism types. *n* (%)					
With the rule	880	361 (41.1)	39 (30.9)	322 (42.7)	0.043*[b]
Against the rule		114 (12.9)	18 (14.3)	96 (12.7)	
Oblique		405 (46.0)	69 (54.8)	336 (44.6)	
Astigmatism types, *n* (%)					
Pure	880	398 (45.2)	31 (24.6)	367 (48.7)	<0.001*[b]
Hyperopic		354 (40.2)	20 (15.9)	334 (44.3)	
Myopic		128 (14.6)	75 (59.5)	53 (7.0)	

*Statistically significant, [a]Independent sample *t*-test, [b]Pearson Chi-square, [c]Fisher's exact test. SD: Standard deviation, URE: Uncorrected refractive error, VI: Visual impairment, BCVA: Best-corrected visual acuity, HVA: Habitual visual acuity, D: diopter

only the presence of a cataract in the eye examination was associated with higher URE, and the history of cataract was not associated with higher URE. The result of the univariable and multivariable models are presented in Table 3.

The variables which did not remain significant in the multivariable model were excluded to create the final model. In the final model, each year of increase in age was associated with 3% higher URE (95% CI: 1.01–1.05). In comparison to

Table 3: Association of different factors with uncorrected refractive error

Variable (referent group)	Univariable		Multivariable	
	OR (95% CI)	P	OR (95% CI)	P
Age	1.02 (1.01–1.03)	0.001*[a]	1.03 (1.01–1.05)	0.001*[a]
Diabetes (no)	1.54 (1.14–2.06)	0.004*[a]	-	-
High astigmatism	5.35 (4.22–7.95)	<0.001*[a]	-	-
Refractive error (low hyperopia)				
Low myopia	4.03 (2.69–6.03)	<0.001*[a]	5.17 (3.38–7.93)	<0.001*[a]
Moderate to high myopia	85.91 (46.03–160.34)	<0.001*[a]	56.23 (21.25–148.83)	<0.001*[a]
High hyperopia	46.78 (18.18–120.35)	<0.001*[a]	127.73 (5.02–250.93)	<0.001*[a]
Anisometropia (no)	6.05 (4.41–8.31)	<0.001*[a]	-	-
Antimetropia (no)	0.26 (0.14–0.47)	<0.001*[a]	0.09 (0.02–0.37)	0.001*[a]
With the rule astigmatism (oblique)	0.59 (0.39–0.89)	0.001*[a]	-	-
Cataract in physical examination (no)	2.71 (1.67–4.44)	<0.001*[a]	-	-

*Statistically significant, [a]Logistic regression, CI: Confidence interval, P/E: Physical examination, OR: Odds ratio

low hyperopia, participants with low myopia had 5.17-times more odds of visually significant URE (95% CI: 3.38–7.93). However, antimetropia decreased the risk of visually significant URE (95% CI: 0.02–0.37).

Discussion

This study described the demographic characteristics and eye examination in participants of the Rafsanjan subcohort of the Persian Eye Cohort. We investigated the predicting variables by comparing participants with and without visually significant URE. Among the participants, 311 out of 6991 had a visually significant URE. An increase in age, myopia, and moderate to severe hyperopia increased the risk of visually significant URE. On the other hand, the presence of antimetropia was associated with lower visually significant URE.

We found that each year of increase in age was associated with a 3% increase in the risk of visually significant URE. This result is similar to previous studies. Varma *et al*. reported an increase in the OR of URE from 0.54 to 2.79 with an increase in age among Americans.[17] Another study in the Mexican population showed that an increase in age was associated with a 1% increase in the risk of visually significant URE.[16] Also, Ferraz *et al*. found an increase in the OR of URE from 0.4 to 1.06 with an increase in age among Brazilians.[15] Moreover, Fotouhi *et al*. reported an increase in the OR of URE from 1.05 to 3.17 with an increase in age in Tehran.[13] This result could be attributed to the increase in refractive errors with the increase in age. Therefore, higher age groups should be considered in the policy-making for a reduction in the prevalence of URE.

Among the participants with refractive error, myopia was associated with higher URE. Prevalence of low myopia was 47.3% in the participants with visually significant URE which was higher than the group without visually significant URE and it was higher than the average prevalence of myopia in the general population (16%–33% in the world and 25%–30% in Iran).[14,28-30] These findings are similar to the previous studies which reported a 3.15–18.67 times increase in the risk of URE among the participants with myopia[13,31,32] This result may suggest that patients with myopia are more prone to visually significant URE and policymakers should pay attention to this group. Furthermore, contact lenses and compact lenses can prevent the use of heavy and thick lenses in patients with moderate to severe myopia and these could facilitate the prevention of URE.

Our results showed that antimetropia was a preventive factor for visually significant URE. For example, if a patient has a SE of 1 in the left eye and -1 in the right eye the correction would be easier than severe refractive error. We hypothesize that due to the lower severity of refractive errors in the patients with antimetropia, visually significant URE was less prevalent among this group.

In this study sex, education, employment, and socioeconomic status were not associated with visually significant URE. These results are similar to some studies,[13,33,34] but they are in contrast with others.[18,35-37] This controversy could be attributed to different population structures and the design of studies. Some studies investigate each factor individually, while we study these factors in the multivariable model.

In this study, diabetes, cataract, visually significant astigmatism, and anisometropia did not have an association with visually significant URE in the multivariable model. Although these variables were significantly associated with visually significant URE in univariable analysis, the result of multivariable analysis suggests that their association may be indirect. We hypothesize that their relationship with refractive errors could be the missing link. Diabetes could result in a change of refraction.[38] Nuclear cataract could lead to a myopic shift while cortical cataract can cause a hyperopic shift in refraction.[39] Similar to our univariable results, some studies have reported an association between mentioned variables and URE.[13,15,22] Future studies on the cataract type and the relationship of blood glucose level with URE could elaborate on this issue. Further studies are necessary to investigate the possible role of fear from aniseikonia in the refractive correction of patients with anisometropia. Furthermore, the use of contact lenses can reduce the practical limitations for refractive correction of patients with high astigmatism in relation to axis modification for reduction of distortion.

This study has several strengths. This study was on the subcohort of the Persian Eye Cohort, and we used a valid questionnaire. Furthermore, the variables were defined based on the international standardized guideline. Our study faced several limitations. Due to the nature of cross-sectional studies, we could not explore the causality. Although we invited all the population with the inclusion criteria to participate in the study, the unwillingness of the participants that did not participate in the study could lead to selection bias. Furthermore, we could not calculate the speculated coverage index and missing data could cause bias in our results.

Our result suggests that policymakers should pay special attention to elderly patients with moderate-to-severe refractive error to effectively reduce the prevalence of visually significant URE. Furthermore, populations with diabetes, cataract, significant astigmatism and anisometropia should also be considered potential targets for the URE reduction programs.

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Conflicts of interest

There are no conflicts of interest.

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