Original Article

Age and Sex Standardized Prevalence of Corneal Opacity and Its Determinants: Tehran Geriatric Eye Study (TGES)

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Abstract

Background: We aimed to determine the age and sex standardized prevalence of corneal opacity and its determinants

Methods: The Tehran Geriatric Eye Study (TGES) is a population-based cross-sectional study conducted on 3791 subjects aged above 60 yr in Tehran, Iran (2019) selected using stratified random cluster sampling. After sampling, all subjects underwent complete ophthalmic, optometric, and eye examinations.

Results: The 3310 participated in the study, of whom the data of 3284 were analyzed. The age and sex standardized prevalence with 95% confidence interval (CI) of corneal opacity in at least one eye, both eyes, and one eye was 9.58% (95% CI: 8.50 to 10.79), 5.52% (95% CI: 4.71 to 6.45), and 4.07% (95% CI: 3.35 to 4.94), respectively. The mean uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) according to LogMar were worse in subjects with corneal opacity (both $P<0.001$). According to multiple logistic regression analysis, male sex (OR: 1.98; P: 0.003), age>80 yr (OR: 2.05; P: 0.004), and lack of insurance coverage (OR: 1.87; P: 0.004) increased the odds and high school education (OR: 0.68; P: 0.003) reduced the odds of corneal opacity. Among the study variables, sex was the most important determinant of corneal opacity (standardized beta: 0.126).

Conclusion: This study found a high prevalence of corneal opacity in the geriatric population. Considering the increasing trend of population aging in Iran, attention should be paid to prioritizing public health policies to estimate resources required for providing comprehensive corneal services and improving geriatric eye health.

Keywords: Corneal opacity; Prevalence; Age-sex-standardized; Geriatric

Introduction

Overall, 253 million people had visual impairment in 2015, of whom 36 million were blind and 217 million had moderate and severe visual impairment (1,2). Despite the decreased prevalence of the causes of blindness in the world due to improved health infrastructures (3). Corneal opacity is still the fifth most common cause of blindness in all age groups across the world with a prevalence of 3.46% (4).

The prevalence of blindness varies in different parts of the world with the highest prevalence reported in less developed countries, indicating the importance of corneal opacity such that it accounts for more than 5% of the cases of blindness in the Middle East (5). While decreased visual acuity is associated with a reduced quality of life and life expectancy, especially in developing countries (6).

The epidemiology of corneal opacity is complex and has changed tremendously in the past decade (6) resulting in different etiologies in different parts of the world. For example, infectious causes including trachoma, malnutrition due to vitamin A deficiency, and traditional treatments of ocular diseases are considered as the main etiologies in developing countries (7,8), while trauma and genetic factors are the leading causes of corneal opacity in developed countries (9,10). This epidemiological shift in the causes of corneal opacity is also seen in countries that are in transition from a least developed status to a developed status (11). However, the causes of corneal opacity accounting for millions of new cases of fictional blindness every year are usually underreported due to lack of diagnosis (12).

Health systems have improved across the world, resulting in quality of life improvement and population aging; therefore, it is necessary to address the complex epidemiology of corneal opacity and its determinants to determine region-specific intervention strategies, which requires valid and reliable data (12). Several studies have estimated the prevalence of corneal opacity in the world and reported different prevalence ranges (9,12-

14). There is limited information from Iran; however, it accounts for 5%-15% of the cases of blindness (15-17). Little information is also available about its epidemiology, including the Shahroud Eye Cohort Study and Rurales Eye Study (18,19).

Since no study has exclusively evaluated the status of corneal opacity in geriatric population and there is a lack of data, this study was conducted to estimate the prevalence of corneal opacity and its determinants.

Methods

Design and sampling

The Tehran Geriatric Eye Study (TGES) was a population-based cross-sectional study conducted in individuals above 60 yr selected through multistage stratified cluster sampling in Tehran, Iran in 2019. Considering a prevalence of 5.2% for visual impairment as the main objective of the study, precision of 1%, and confidence interval of 95%, the sample size was estimated at 1894 subjects. After applying a design effect of 1.5 and a non-response rate of 10% (sample size/(1-non-response rate)), the sample size was calculated at 3155 subjects, which was rounded up to 3200 participants.

In the first step, each district of Tehran was considered as a stratum (22 strata), the over 60-year-old population of each district was obtained from the Statistical Center of Iran, and the population that was to be selected from each district was determined in a proportional to size manner. Then, the block-by-block map of each district was provided and each block was considered a cluster. Next, 160 were randomly selected from all 22 districts such that the number of clusters in each district was proportional to its population.

Optometric examinations started with refraction measurement using the auto ref/keratometer ARK-510A (Nidek Co. LTD, Aichi, Japan) followed by the measurement of uncorrected visual acuity (UCVA) and best-corrected visual acuity

(BCVA) using the Smart LC 13 LED visual chart (Medizs Inc., Korea) at 6 m. Then, the anterior and posterior segments were examined by an ophthalmologist using the B900 biomicroscope (Haag-Streit AG, Bern, Switzerland) and a +90 D lens. In this study, corneal opacity was evaluated through examination of the entire cornea at various depths in different areas to observe areas of lost transparency ranging from superficial to deep opacities, which may be central or peripheral to the cornea. The data of 15 household assets were collected to generate the economic status variable quantitatively using principal component analysis (PCA) and the participants were categorized into high, intermediate, and low economic status categories. Moreover, to construct the socioeconomic status (SES), the data of seven 13 assets were collected and a wealth index was generated using principle component analysis according to the weighting of the first component. Then, based on wealth index the participants were divided into three groups (Low, Middle and High economic group).

Statistical analysis

To estimate the age and sex-standardized prevalence of corneal opacity, the samples were weighted according to Tehran's population. Then, the percentage and 95% confidence interval of corneal opacity were calculated. Simple and multiple logistic regression analyses were used to investigate the relationship between corneal opacity and its determinants. A standardized coefficient was calculated to compare the strength of the effect of each independent variable to the dependent variable. Standardized coefficients have standard deviations as their units and this means the variables can be easily compared to each other. The higher the absolute value of the standardized coefficients, showed the stronger effect. Since we used the stratified cluster sampling, the design effect of cluster sampling was considered for standard error correction due to within-cluster correlation. The Stata software was used for data analysis. *P*-values less than 0.05 were considered significant.

Ethical issues

This study was approved by the Ethics Committee of National Institute for Medical Research Development affiliated with the Iranian Ministry of Health and Medical Education. The tenets of the Helsinki Declaration were followed and informed consent was obtained from all participants.

Results

Of 3791 subjects invited, 3310 participated in the study (response rate=87.31%), of whom the data of 3284 were analyzed. The mean age of the subjects was 69.35±7.62 yr (range=60-97 yr). Moreover, 1899 (57.83%) were female, 412 (12.55%) had university education, and 2429 (73.96%) were married. The age and sex-standardized prevalence of corneal opacity in at least one eye was 9.58% (95% CI: 8.50 to 10.79). The age and sex-standardized prevalence of bilateral and unilateral corneal opacity was 5.52% (95% CI: 4.71 to 6.45) and 4.07% (95% CI: 3.35 to 4.94), respectively. The prevalence of corneal opacity was 7.64% (95% CI: 6.68 to 8.74) in the right eye and 7.45% (95% CI: 6.51 to 8.52) in the left eye. According to the involved corneal layer, of 225 subjects with corneal opacity of the right eye, epithelial, stromal, superficial, and endothelial involvement was seen in 102 (45%), 207 (92%), 205 (91%), and 6 (3%) subjects, respectively. Of 220 subjects with corneal opacity of the left eye, epithelial involvement was seen in 99 (45%), superficial involvement was observed in 201 (91%), and endothelial involvement was detected in 8 subjects (4%).

Table 1 shows the age and sex-standardized prevalence with 95% confidence interval (CI) of corneal opacity according to determinants. The highest prevalence of corneal opacity was seen in the age group 80 yr and more [16.43% (95% CI: 12.01 to 22.09)] and the lowest prevalence was seen in the age group 60-64 yr [7.10% (95% CI: 5.49 to 9.14)]. As for the education level, the highest and lowest prevalence was seen in illiterate subjects [13.14% (95% CI: 9.59 to 17.76)]

and those with high school education [7.91% (95% CI: 5.24 to 11.78)], respectively. The prevalence of corneal opacity was 11.17% (95% CI: 9.52 to 13.08) in men and 8.01% (95% CI: 6.71 to 9.54) in women. According to occupation, the lowest prevalence was seen in unemployed individuals [7.14% (95% CI: 2.85 to 16.79)]. Table 1 shows the prevalence of corneal opacity according to insurance coverage, history of surgery, and economic status.

Table 1: Prevalence of corneal opacity according to determinants

Variable		Number	Prevalence% (95% CI)
Sex	Male	1385	11.17 (9.52 to 13.08)
	Female	1899	8.01 (6.71 to 9.54)
Age (yr)	60-64	1154	7.10 (5.49 to 9.14)
	65-69	949	7.99 (6.38 to 9.97)
	70-74	631	8.67 (6.73 to 11.09)
	75-79	311	14.00 (10.47 to 18.47)
	80 and more	239	16.43 (12.01 to 22.09)
Education	Illiterate	441	13.14 (9.59 to 17.76)
	Primary School	1007	10.21 (8.08 to 12.83)
	Middle School	608	10.40 (7.92 to 13.55)
	High School	816	6.89 (5.31 to 8.90)
	College	412	7.91 (5.24 to 11.78)
Employment	Employed	109	14.63 (8.90 to 23.14)
	Retired	1430	9.80 (8.25 to 11.61)
	Unemployed	43	7.14 (2.85 to 16.79)
	Housekeeper	1610	8.47 (7.02 to 10.19)
	Disabled and others	92	15.98 (9.24 to 26.22)
Insurance	Yes	3025	9.05 (7.91 to 10.32)
	No	255	15.95 (11.34 to 21.95)
History of eye surgery	Yes	1121	11.87 (9.97 to 14.08)
	No	2163	8.22 (6.97 to 9.56)
SES	Low	1158	11.57 (9.48 to 14.03)
	Middle	1032	8.48 (6.72 to 10.65)
	High	1094	8.38 (6.63 to 10.55)
Total		3284	9.58 (8.50 to 10.79)
CI: Confidence Interval; SES: Socio-Economic Status			

Table 2 shows the results of simple and multiple logistic regression analysis between corneal opacity and determinants. According to the multiple model, corneal opacity had a direct association with male sex (OR: 1.59; 95% CI: 1.23 to 2.05) and age (OR for 75-79 and ≥80 vs 60-64: 2.00; 95% CI: 1.32 to 3.04 and 2.24; 95% CI: 1.42 to 3.54; respectively). Moreover, an inverse association was observed between corneal opacity and high school education level (OR: 0.68; 95% CI: 0.45 to 0.98). The odds of corneal opacity were higher in employed subjects versus housekeepers; however, this relationship was not seen in the multiple model. Moreover, the odds of corneal opacity were 1.87 times higher for subjects lacking insurance coverage compared to insured subjects (*P*: 0.004). The AIC and Pseudo R^2 of model were 1649.804 and 0.0320; respectively. Among different variables, sex (standardized beta: 0.126) and age (standardized beta: 0.111) had the highest effect on corneal opacity.

Table 2: Association of corneal opacity and its determinant based on simple and multiple logistic regression

Variable		Simple Logistic Regression		Multiple Logistic Regression		
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	Standardized beta
Sex (Female=0)		1.70 (1.34 to 2.16)	<0.001*	1.98 (1.16 to 3.40)	0.013*	0.126
Age group (60-64=0)	65-69	1.23 (0.86 to 1.77)	0.255	1.14 (0.79 to 1.65)	0.490	0.111
	70-74	1.39 (0.94 to 2.05)	0.102	1.16 (0.77 to 1.75)	0.480	
	75-79	2.44 (1.62 to 3.67)	<0.001*	1.92 (1.22 to 3.01)	0.005*	
	80 and more	2.98 (1.96 to 4.52)	<0.001*	2.05 (1.27 to 3.31)	0.004*	
Education (illiterate=0)	Primary school	0.82 (0.57 to 1.20)	0.305	0.93 (0.64 to 1.36)	0.710	-0.065
	Middle school	0.81 (0.53 to 1.24)	0.326	0.94 (0.61 to 1.46)	0.788	
	High school	0.54 (0.37 to 0.80)	0.002*	0.68 (0.45 to 0.98)	0.045*	
	College	0.57 (0.35 to 0.94)	0.028*	0.7 (0.39 to 1.25)	0.226	
Employment (housekeeper =0)	Employed	2.02 (1.15 to 3.55)	0.015*	1.06 (0.51 to 2.24)	0.869	-0.005
	Retired	1.29 (1.01 to 1.64)	0.043*	0.76 (0.42 to 1.38)	0.369	
	Unemployed	1.30 (0.48 to 3.47)	0.602	0.52 (0.17 to 1.57)	0.246	
	Other	2.46 (1.36 to 4.45)	0.003*	0.76 (0.32 to 1.85)	0.550	
Insurance (Yes=0)	No	2.12 (1.45 to 3.09)	<0.001*	1.87 (1.22 to 2.86)	0.004*	0.086
Eye surgery history (No=0)	Yes	1.46 (1.15 to 1.85)	0.002*	1.14 (0.88 to 1.49)	0.325	0.065
SES (Low=0)	Middle	0.80 (0.58 to 1.10)	0.171	0.94 (0.68 to 1.30)	0.709	-0.055
	High	0.70 (0.50 to 0.96)	0.026*	0.99 (0.69 to 1.42)	0.951	

CI: Confidence Interval; *: Significance; OR: Odds Ratio; SES: socioeconomic status.

The mean UCVA was 0.52±0.61 and 0.34±0.46 LogMar and the mean BCVA was 0.31±0.53 and 0.14±0.38 LogMar in subjects with and without corneal opacity (both *P*<0.001).

Discussion

The results of the Tehran Geriatric Eye Study as the first population-based study exclusively conducted in subjects above 60 yr in Iran may help health policy makers to determine the eye care services required for the elderly population and to eliminate the causes of avoidable corneal blindness and visual impairment.

Several studies estimated the prevalence of corneal opacity in the world (Table 3) (9,12-14, 18-21). The age and sex standardized prevalence of corneal opacity was 9.58% in the present study. Gupta et al. (14) reported a prevalence of 26% in subjects above 60 yr in India and Haq et al. (12) found a prevalence of 14.5% in people older than 60 yr, which were higher than the results of the

present study. Singh et al. (13) studies individuals above 60 yr in India and estimated a prevalence of 3% for corneal opacity.

Table 3: Characteristics of similar studies investigating prevalence of corneal opacity in different regions

Author	Place/study	Design	Age (yr)	SS	Prevalence% (95% CI)
13	Maharashtra state/ India	Population based	> 50	903	3.00 (1.97 – 4.32)
9	Nigeria	Hospital-based	All age	3573	18.90
20	Myanmar	Population based	> 40	2076	1.30 (0.85 – 1.89)
21	Veterans/ USA	Medical Record based	> 55	782	3.73 (3.31 – 4.17)
12	Adult Population of Aligarh/ India	Population based	> 20	645	4.18 (2.77 – 6.03)
14	CORE study/ India	Population based	> 15	12113	3.70 (3.4 – 4.10)
19	Rural eye study/ Iran	Population based	> 5	3314	1.68 (1.08 – 2.27)
18	Shahroud Eye Co-hort Study/ Iran	Population based	40-64	5190	4.10 (3.40 – 4.70)
Current Study	TGES/ Iran	Population based	> 60	3284	9.58 (8.50 – 10.79)

The prevalence of corneal opacity in this study was higher than some foreign studies, including a study of subjects above 40 yr in Myanmar (20) and veterans over 50 yr in the US,(21) and even higher than some domestic studies, including the Shahroud Eye Cohort Study (prevalence of 4.1% in subjects 49-64 yr) (18) and the Rural Eye Study (prevalence of 7.5% in subjects above 60 yr) (19) . Lack of knowledge about ocular health and poor access to eye healthcare services in the elderly population may be the reasons for the higher prevalence of corneal opacity in this study compared to studies conducted in Iran and other countries. However, differences in the age structure of participants between studies may also be one of the most important reasons for the discrepancy in results.

The results of the present study showed a direct association between age and prevalence of corneal opacity. Previous studies also found an increase in the prevalence of corneal opacity with age (12,14,18-20), which was attributed to cumulative effect of exposure to environmental factors (18) increasing degenerative conditions (13), and corneal changes and reduced transparency secondary to age-related factors (22,23). The prevalence of many other ocular diseases increases with age (12,17,18,21-28), and therefore this trend was expectable.

There are controversies regarding the effect of male sex on corneal opacity. This study found a higher prevalence of corneal opacity in men, which was in line with some other studies (18,19). However, some studies found a higher prevalence in women (12,14). The reason for this difference could be inter-gender hormonal differences and some hormonal changes after menopause in women (12,18). Nonetheless, this may not be a proper explanation since all women were above 60 yr and menopausal in the present study. Men are more exposed to risk factors including infections, environmental factors like sunlight

exposure, and trauma due to more outdoor activities (18,19) and therefore carry a higher risk of corneal opacity. The higher prevalence of ocular trauma and other corneal diseases in men on the one hand (12,18,29) and a standardized beta of 0.126 for sex (which was the highest among variables) on the other hand support this hypothesis. Gupta et al.(14) reported a relationship between occupation and corneal opacity such that its prevalence was lower in subjects doing housework. Although the present study found an association between occupation and corneal opacity such that its prevalence was higher in employed and retired subjects compared to housekeepers, this relationship was not significant in the multiple model suggesting no association between occupation and corneal opacity. The lowest standardized beta was related to occupation, which supports this hypothesis.

In line with other studies (13,14), the present study found an inverse association between economic status and education level and corneal opacity such that the odds of corneal opacity were lower in participants with high school education compared to illiterate subjects. Hashemi et al.(19) found no association between education level and corneal opacity and attributed this finding to the overall lower education level in rural areas under study; however, people with higher education levels have more knowledge, income, and access to safety facilities, resulting in a lower risk of corneal opacity (19).

Another finding of the present study was difference in visual acuity between subjects with corneal opacity and healthy participants, such that the mean UCVA and BCVA were 0.18 and 0.17 worse in subjects with corneal opacity, respectively. Some other studies found similar results (18, 19, 30), indicating the involvement of the central cornea and visual axis (18). A prevalence of 46.2% for visual impairment was found in subjects with corneal opacity (19) and Li et al. estimated a prevalence of 0.95% for corneal blindness (30). The importance of the effect of corneal opacity on visual acuity lies in the fact that low visual acuity disturbs the quality of life and everyday activities (6).

The results of the present study as the first population-based study exclusively conducted in the elderly population of Tehran, Iran may help health policymakers to estimate the resources required to provide comprehensive corneal services. A large sample size, a high participation rate, conducting examinations according to a well-designed protocol, and using trained staff were among the strengths of this study. The authors were interested in determining the causes of corneal opacity and evaluating its grade but the required infrastructures were lacking, which could be considered a limitation.

Conclusion

The prevalence of corneal opacity was higher in this study compared to some other studies conducted in Iran and other countries, indicating the unfavorable condition of the elderly population and the need for giving priority to this age group for allocation of resources. This study evaluated the effect of some determinants on corneal opacity and found that older age, male sex, low education level, and lack of insurance increased the odds of corneal opacity. The results of this study can be used to design strategies to reduce the burden of corneal opacity and improve the overall geriatric ocular health status.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

No conflicting relationship exists for any author.

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