



Original research

The prevalence of refractive errors in 5–15 year-old population of two underserved rural areas of Iran

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Abstract

Purpose: To determine the prevalence of hyperopia and myopia and their associations with age and gender in 5- to 15-year-old children in underserved rural areas in Iran.

Methods: In this cross-sectional study, sampling was done using a multistage cluster sampling method from two underprivileged rural regions in Iran, and 3851 persons over 1 year old of age were invited to the study. After inviting the selected participants, examinations were conducted at a designated site in the selected villages. All participants underwent measurements of uncorrected and corrected visual acuity, manifest refraction, and a slit-lamp examination. Cycloplegic refraction was done by instilling cyclopentolate 1% eye drops in under 15-year-old participants.

Results: Of the 3851 selected persons, 3314 subjects participated (86.5%), and of these, 602 were in the 5–15 year age group. The prevalence of myopia and hyperopia in the studied children was 2.60% [95% confidence interval (CI): 1.10–4.10] and 4.00% (95% CI: 1.84–6.15), respectively. The prevalence of myopia in male and female children was 2.65% and 2.55%, respectively ($P = 0.951$). The prevalence of hyperopia in male and female children was 2.83% and 5.25%, respectively ($P = 0.130$). The prevalence of myopia in the villages of southwest and north was 2.42% and 3.09%, respectively ($P = 0.618$), and the prevalence of hyperopia was 4.71% and 2.10%, respectively ($P = 0.0056$).

Conclusion: The present report is a brief description of the status of refractive errors in children residing in underprivileged villages of two rural districts in Iran. As presented, the prevalence of myopia is not high, although the prevalence of hyperopia is in the mid-range compared to previous studies.

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Keywords: Myopia; Hyperopia; Cross-sectional study; Rural population; Children

Introduction

Refractive errors are the leading cause of visual impairment in the world and account for a great share of visual impairment. A review in 2010 by Naidoo stated that 6.8 million people in the world are blind due uncorrected refractive errors, and 101.2 million are visually impaired.¹ Refractive errors are vision disorders that can affect an individual throughout their

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lifetime, and they are the most common vision problem in most age groups. Children are one of the most important populations at risk of refractive errors, and such visual problems can impact their learning experiences and future occupational opportunities.

Over the past two decades, the distribution of refractive errors in children around the world has been an issue of interest. In 2000, a report by Negrel on refractive errors presented a protocol for determining refractive errors in children.² According to this protocol, refractive errors in 5–15-year-old children should be measured under cycloplegia. Since then, numerous studies around the world have based their work on this protocol to describe the prevalence of refractive errors in children.^{2–17} Although we expect a higher prevalence of hyperopia in children, a review of these study results suggests that myopia can be more common than hyperopia, and there is agreement that myopia is more common in East Asian populations.^{2–16}

In Iran, the protocol for refractive errors in children was first followed by Fotouhi et al to determine the prevalence of refractive errors in children in Dezful,¹² and since then, several other studies in various parts of Iran have described refractive errors using the same protocol.^{3,5,12} However, except for the study by Fotouhi et al whose samples were partly selected from rural areas,¹² all other reports from Iran concern urban children. Overall, studies on rural populations are less common throughout the world.^{7,8,11,13,18} Given their less access to health services, it is essential to direct attention to rural populations. The present report is part of a larger study conducted at underprivileged rural areas in Iran. Given the limited number of reports from rural areas and the importance of children's visual status, the purpose of the present report is to describe the prevalence of refractive errors in rural children.

Methods

Sampling method

The present study was conducted cross-sectionally in 2015. In this study, the residents of deprived villages were considered as the target population, and it was conducted at rural areas of two underprivileged districts in Iran. For sampling, a multistage cluster sampling approach was applied to select potential participants. One of the offices of the presidential administration in Iran is dedicated to the development of rural and deprived areas of the country. The sampling frame of the present study was based on the roster of deprived rural villages provided by this office. For this purpose, national data was used to randomly select two districts from the north and southwest of the country. The district selected from the north was Kajour (a district of Noshahr County, Mazandaran Province), and the selected district from the southwest was Shahyoun (a district of Dezful County, Khuzestan Province). In the next stage, rosters of all villages in these two districts were prepared, and a number of them were randomly selected.

Since a main objective of this survey was to evaluate visual impairment, the sample size was calculated based on the prevalence of visual impairment in a village in Iran. The

sample size for a rate of 6.3%, a precision level of 0.01 and a 95% confidence interval (CI) was calculated as 2267. Considering the sampling method, a 1.5 design effect was considered, which corrected the sample size to 3400. Also, a 10% non-response rate was assumed with the total sample size reached 3740. Sampling from each district was proportional to their total population. Therefore, given the sample size calculated for the study, 5 villages were sampled in Kajour and 15 in Shahyoun to maintain the balance, because the latter district had smaller and less populated villages. All over-one-year-old rural-dwellers in each selected village were considered as a study sample and invited to participate in the study.

Examinations in each village were completed at a site with normal room illumination. After obtaining consents and conducting an interview to obtain demographic information, all participants underwent optometric examinations. All optometric examinations were performed by two experienced optometrists. These two optometrists had high inter-examiner agreement on initial testing of uncorrected visual acuity (Interclass Correlation Coefficient (ICC): 0.92) and spherical equivalent of refraction (ICC: 0.90) in 35 subjects.

First, all participants were examined with an auto-refractometer (Nidek ARK-510A Auto Refractor/Keratometer, Japan) to record their objective refraction, and then their uncorrected distance visual acuity (UCVA) was measured using a Snellen E chart at a distance of 6 m. Visual acuity testing for children who were uncooperative with Snellen chart, was done with LEA symbols acuity chart (LEA Symbols Acuity Chart, Good-Lite Company, USA).

In the next stage, after refining the auto-refraction with retinoscopy (Heine Beta 200 retinoscope, HEINE Optotechnik, Germany), all cooperative cases with an UCVA worse than 20/20 were tested for subjective refraction. After the completion of vision tests, all participants had ophthalmic and slit-lamp examinations by an ophthalmologist.

Finally, all participants 15 years of age and younger underwent cycloplegic refraction. For this purpose, a drop of cyclopentolate 1% was instilled in each eye, twice, 5 min apart, and cycloplegic refraction with the auto-refractometer was done 35 min after the last drop.

To allow for proper comparison of our results with other studies using the Negrel's refractive status evaluation protocol for children, participants over 15 years of age and also those under 5 years of age were excluded from this report.

Definitions

Refractive errors were determined based on spherical equivalent refraction. A spherical equivalent of -0.5 diopter (D) or worse was defined as myopia and a spherical equivalent equal to or worse than 2.00 D was defined as hyperopia.

Statistical analysis

The prevalence of myopia and hyperopia are presented as percentages with 95% CI. In calculating the 95% CI, adjustments for the effect of cluster sampling were considered. For

every rural area, weighting of the sample was done according to age and gender. To investigate the relationship between refractive errors and the variables of age, gender and area of residence, we used multiple logistic regressions.

Ethical issues

The Ethics Committee of Tehran University of Medical Sciences approved the study protocol, which was conducted in accord with the tenets of the Declaration of Helsinki. All participants signed a written informed consent.

Results

Of the 3851 subjects selected for the study, 3314 participated (86.5%), and of these, 656 were in the 5–15 year age group. After excluding cases who met the exclusion criteria, data from 602 participants was used in the analysis for this report. Female participants comprised 51.2% (n = 308) of the sample. The mean age of the studied sample was 10.02 ± 3.19 years.

Table 1 shows the prevalence of refractive errors by age and gender. The prevalence of myopia and hyperopia in the total sample was 2.60% (95% CI: 1.10–4.10) and 4.00% (95% CI: 1.84–6.15), respectively. The prevalence of myopia in male and female children was 2.65% (95% CI: 0.40–4.89) and 2.55% (95% CI: 0.35–4.75), respectively (P = 0.951). The lowest prevalence of myopia was observed in the 5–7 year age group (1.16%) and the highest was in the 14–15 year age group (5.94%). By considering the 5–7 year age group as the reference group, simple regression model indicated an age-related increase in the prevalence of myopia (P < 0.001).

Table 1
The prevalence of myopia and hyperopia by age and gender.

		Myopia		Hyperopia	
		% (95% CI)		% (95% CI)	
Gender	Total	n	2.60 (1.10–4.10)	4.00 (1.84–6.15)	
	Female	308	2.55 (0.35–4.75)	5.25 (1.49–9.00)	
	Male	294	2.65 (0.40–4.89)	2.83 (1.13–4.53)	
Age	5–7	164	1.16 (0.14–9.82)	4.84 (0.50–9.18)	
	8–10	165	0.77 (0.09–6.70)	3.40 (1.25–9.26)	
	11–13	151	2.56 (0.28–4.85)	4.30 (1.57–11.75)	
	14–15	122	5.94 (0.62–11.27)	3.44 (0.54–21.71)	
	Place	Southwest	371	2.42 (0.58–4.25)	4.71(1.73–7.69)
	North	231	3.09 (0.96–5.21)	2.10 (0.98–3.22)	

CI: Confidence interval.

Table 2
The association between myopia and hyperopia with gender, area of residence and age by multiple regressions logistic.

		Hyperopia		Myopia	
		OR (95% CI)	P-value	OR (95% CI)	P-value
Gender	Male/female	0.52 (0.23–1.21)	0.120	1.04 (0.31–3.49)	0.941
Area of residence	North/Southwest	0.43 (0.18–1.03)	0.058	1.25 (0.49–3.18)	0.619
Age	5–7	1		1	
	8–10	0.68 (0.2–2.34)	0.520	0.66(0.03–15.2)	0.784
	11–13	0.88 (0.15–5.14)	0.879	2.25(0.18–27.7)	0.501
	14–15	0.70 (0.12–4.31)	0.686	5.38(0.39–74.85)	0.193

OR: Odd ratio; CI: Confidence interval.

The prevalence of hyperopia in males and females was 2.83% (95% CI: 1.13–4.53) and 5.25% (95% CI: 1.49–9.00), respectively (P = 0.130). The lowest prevalence of hyperopia was observed in the 14–15 year age group (3.44%), and the highest was in the 5–7 year age group (4.84%). By considering the 5–7 year age group as the reference group, the simple regression model showed no statistically significant relationship between age and the prevalence of hyperopia (Table 2).

Table 1 also shows the prevalence of myopia and hyperopia according to the area of residence. Based on the simple logistic regression, there was no statistically significant difference in the prevalence of myopia (P = 0.618) and hyperopia (P = 0.0056) between the children of southwest and north.

Table 2 shows the results of the multiple logistic regression for myopia and hyperopia. As seen, there was no statistically significant relationship between the prevalence of myopia and hyperopia with study's variables (all P values >0.05).

Discussion

This brief report describes the prevalence of refractive errors in underprivileged rural areas in Iran. To allow for proper comparisons, here we only discuss results in 5–15-year-old children who had cycloplegic refraction. Table 3 summarizes the results of other studies based on children's refractive error protocol; as demonstrated, the prevalence of myopia in children around the world varies between 0.3% in Nepal to 36.7% in Hong Kong (Table 3), while the prevalence in our study was 2.60%.

The prevalence of myopia in this study was relatively lower than studies outside Iran and even studies conducted in Iran.^{4,6–10,13–16,18,20–25} The increase in myopia prevalence is being attributed to lifestyle changes, especially near work, and the results of this study indicate that children in underprivileged villages, unlike urban children, are probably spared from myopia because of their lack of access to common near work devices, however, given the global growing trend of myopia, prevention programs including limiting near activities and encouraging children to participate more in outdoor activities may be helpful for rural areas.

The prevalence of hyperopia varies from 0.8% in Nepal to 18.3% in Morocco (Table 3), and our study showed that 4.00% of the children were hyperopic. The prevalence of hyperopia in our study is in the mid-range, although as seen in Table 3,

Table 3
Summary of other studies concerning myopia and hyperopia (childhood).

Country	Year of publication	Age (year)	Sample size	Myopia	Hyperopia
Iran (Bojnourd) ⁵	2012	6–17	1551	4.3%	5.4%
Iran (Shiraz) ³	2010	7–15	1872	1.73%	8.95%
Pakistan ¹⁹	2014	5–16	45122	1.89%	0.63%
Cambodia ¹¹	2012	12–14	5527	2.2%	0.4%
Iran (Dezful) ¹²	2007	7–15	5544	2.5%	28.9%
India ⁷	2009	6–15	12422	3.16%	1.06%
Turkey ²⁰	2013	6–14	21062	3.2%	5.9%
India ¹³	2002	7–15	4074	4.1%	0.78%
Malaysia ¹⁰	2008	6–12	705	5.4%	1.0%
Ethiopia ²¹	2014	7–15	420	5.47%	1.4%
Chili ⁹	2000	5–15	5303	5.8%	14.5%
Ethiopia ⁸	2013	7–18	4238	6.0%	0.33%
Sweden ²²	2006	4–15	143	6%	9%
Morocco ¹⁵	2009	6–16	545	6.1%	18.3%
Poland ¹⁴	2007	6–18	5724	13%	38%
China ⁶	2010	6–15	3070	13.75%	3.26%
Nepal ²³	2012	5–15	133	34%	15%
Nepal ¹⁸	2010	7–15	440	59.8%	31.0%
Saudi Arabia ¹⁶	2013	5–15	2246	65.7%	9.9%

the prevalence of hyperopia is relatively high in this study compared with some other parts of the world. This observation may be a little hard to explain, however, based on previous reports, hyperopia is more common at lower levels of education and lower economic status.²⁶ It seems that less access to digital devices (demanding near visual activity) such as laptops on one hand, and lack of proper nutrition on the other hand can be responsible for the higher rate of hyperopia in rural children.²⁷

Although there are studies which reject this relationship, these findings have been confirmed by multiple studies. We believe that a major part of these findings can be attributed to changes in the axial length.^{28,29} Age-related axial elongation of the eye is associated with higher chances of myopia, especially at 5–15 years of age when emmetropization occurs.²⁸

According to the results of this study, the prevalence of myopia increased from 1.16% in 5–7 year age group to about 6% in 14–15 year age group, and the relation between age and myopia prevalence was statistically significant according to the simple logistic regression model, but this significant relationship was not maintained in the multiple logistic regression. However, we believe that this may be due to the low event of myopia across age groups.

The strength of this study was compliance with the protocol for studying refractive errors in children and use of cycloplegic refraction. Describing the distribution of refractive errors in a rural population is another advantage of the study. However, the small sample size and sampling approach with selection of only two rural regions makes it difficult to generalize results, and these limitations should be taken into consideration.

In conclusion, the present report is a brief description of the status of refractive errors in children residing in underprivileged villages of two rural districts in Iran. As presented, the prevalence of myopia is not high, although the prevalence of

hyperopia is in the mid-range compared to previous studies. Older age is a risk factor related to myopia. Rural-dwellers' desire for urban migration and the higher rate of risk factors in urban life or their extension to rural areas can increase the prevalence of refractive errors in villages.

References

- Naidoo KS, Leasher J, Bourne RR, et al. Global vision impairment and blindness due to uncorrected refractive error, 1990–2010. *Optom Vis Sci.* 2016;93(3):227–234.
- Negrel AD, Maul E, Pokharel GP, Zhao J, Ellwein LB. Refractive Error Study in Children: sampling and measurement methods for a multi-country survey. *Am J Ophthalmol.* 2000;129(4):421–426.
- Yekta A, Fotouhi A, Hashemi H, et al. Prevalence of refractive errors among schoolchildren in Shiraz, Iran. *Clin Exp Ophthalmol.* 2010;38(3):242–248.
- Villarreal GM, Ohlsson J, Cavazos H, Abrahamsson M, Mohamed JH. Prevalence of myopia among 12- to 13-year-old schoolchildren in northern Mexico. *Optom Vis Sci.* 2003;80(5):369–373.
- Rezvan F, Khabazkhoob M, Fotouhi A, et al. Prevalence of refractive errors among school children in Northeastern Iran. *Ophthalmic Physiol Opt.* 2012;32(1):25–30.
- Pi LH, Chen L, Liu Q, et al. Refractive status and prevalence of refractive errors in suburban school-age children. *Int J Med Sci.* 2010;7(6):342–353.
- Padhye AS, Khandekar R, Dharmadhikari S, Dole K, Gogate P, Deshpande M. Prevalence of uncorrected refractive error and other eye problems among urban and rural school children. *Middle East Afr J Ophthalmol.* 2009;16(2):69–74.
- Mehari ZA, Yimer AW. Prevalence of refractive errors among schoolchildren in rural central Ethiopia. *Clin Exp Optom.* 2013;96(1):65–69.
- Maul E, Barroso S, Munoz SR, Sperduto RD, Ellwein LB. Refractive error study in children: results from La Florida, Chile. *Am J Ophthalmol.* 2000;129(4):445–454.
- Hashim SE, Tan HK, Wan-Hazabbah WH, Ibrahim M. Prevalence of refractive error in Malay primary school children in suburban area of Kota Bharu, Kelantan, Malaysia. *Ann Acad Med Singap.* 2008;37(11):940–946.
- Gao Z, Meng N, Muecke J, et al. Refractive error in school children in an urban and rural setting in Cambodia. *Ophthalmic Epidemiol.* 2012;19(1):16–22.
- Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful. *Iran Br J Ophthalmol.* 2007;91(3):287–292.
- Dandona R, Dandona L, Srinivas M, et al. Refractive error in children in a rural population in India. *Invest Ophthalmol Vis Sci.* 2002;43(3):615–622.
- Czepita D, Mojsa A, Ustianowska M, Czepita M, Lachowicz E. Prevalence of refractive errors in schoolchildren ranging from 6 to 18 years of age. *Ann Acad Med Stetin.* 2007;53(1):53–56.
- Anera RG, Soler M, de la Cruz Cardona J, Salas C, Ortiz C. Prevalence of refractive errors in school-age children in Morocco. *Clin Exp Ophthalmol.* 2009;37(2):191–196.
- Al Wadaani FA, Amin TT, Ali A, Khan AR. Prevalence and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. *Glob J Health Sci.* 2012;5(1):125–134.
- Ostadi-Moghaddam H, Fotouhi A, Khabazkhoob M, Heravian J, Yekta AA. Prevalence and risk factors of refractive errors among schoolchildren in Mashhad, 2006–2007. *Iran J Ophthalmol.* 2008;20(3):3–9.
- Pokharel A, Pokharel PK, Das H, Adhikari S. The patterns of refractive errors among the school children of rural and urban settings in Nepal. *Nepal J Ophthalmol.* 2010;2(2):114–120.
- Gull A, Raza A. Visual Screening and Refractive Errors among school aged children. *J Rawalpindi Med Coll (JRMCC).* 2014;18:97–100.
- Caca I, Cingu AK, Sahin A, et al. Amblyopia and refractive errors among school-aged children with low socioeconomic status in southeastern Turkey. *J Pediatr Ophthalmol Strabismus.* 2013;50(1):37–43.

21. Sewunet SA, Aredo KK, Gedefew M. Uncorrected refractive error and associated factors among primary school children in Debre Markos District, Northwest Ethiopia. *BMC Ophthalmol.* 2014;14:95.
22. Grönlund MA, Andersson S, Aring E, Hård AL, Hellström A. Ophthalmological findings in a sample of Swedish children aged 4–15 years. *Acta Ophthalmol Scand.* 2006;84(2):169–176.
23. Rai S, Thapa HB, Sharma MK, Dhakhwa K, Karki R. The distribution of refractive errors among children attending Lumbini Eye Institute. *Nepal Nepal J Ophthalmol.* 2012;4(1):90–95.
24. Ayed T, Sokkah M, Charfi O, El Matri L. Epidemiologic study of refractive errors in schoolchildren in socioeconomically deprived regions in Tunisia. *J francais d'ophtalmologie.* 2002;25(7):712–717.
25. Congdon N, Wang Y, Song Y, et al. Visual disability, visual function, and myopia among rural Chinese secondary school children: the Xichang Pediatric Refractive Error Study (X-PRES)—report 1. *Invest Ophthalmol Vis Sci.* 2008;49(7):2888–2894.
26. Hashemi H, Khabazkhoob M, Jafarzadehpur E, et al. High prevalence of myopia in an adult population, Shahroud, Iran. *Optom Vis Sci.* 2012;89(7):993–999.
27. Kim Y, Choi HJ, Lee SY. The relationship between ophthalmic refractive errors and factors of nutrition and health. *Korean J Community Nutr.* 2000;5(4):608–614.
28. Hashemi H, Jafarzadehpur E, Ghaderi S, et al. Ocular components during the ages of ocular development. *Acta Ophthalmol.* 2015;93:74–81.
29. Hashemi H, Khabazkhoob M, Miraftab M, et al. The distribution of axial length, anterior chamber depth, lens thickness, and vitreous chamber depth in an adult population of Shahroud, Iran. *BMC Ophthalmol.* 2012;12:50.