

# Prevalence of Refractive Errors among the Elderly Population of Sari, Iran

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## Abstract

**Purpose:** To determine the prevalence of the refractive errors in the elderly population of Sari, Iran

**Methods:** In this study, after selecting the participants through random cluster sampling, they all received ocular examinations including visual acuity (VA) measurement, refraction, funduscopy and tonometry. After measuring uncorrected visual acuity (UCVA), non-cycloplegic refraction was performed for all participants with an autorefractometer and the results were checked with manual retinoscopy.

**Results:** The prevalence of myopia, hyperopia, astigmatism and anisometropia were 19.7% [95% confidence interval (CI) 17.0-22.4], 39.5% (95% CI 36.1-42.9), 23.6% (95% CI 20.7-26.4), and 7.8% (95% CI 6.0-9.6), respectively. Male gender and cataract were also significantly correlated with myopia. Female gender and age were correlated with hyperopia. Astigmatism was significantly correlated with cataract and a decrease in age. With-the-rule (WTR), against-the-rule (ATR) and oblique astigmatisms were detected in 7.5%, 13.1% and 3.5% of the participants, respectively. Overall, the prevalence of at least one type of refractive error was 64.0% (95%CI 60.7-67.3) among the participants.

**Conclusion:** The results of this study indicated that hyperopia was the major anomaly in our population. Since the combination of presbyopia and hyperopia results in an undesirable visual condition in the elderly, it is important to pay proper attention to visual problems in this age group.

**Keywords:** Refractive Errors, Elderly, Population Based Study, Iran, Prevalence

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## Introduction

Uncorrected refractive errors are one of the major causes of visual impairment worldwide,<sup>1</sup> according to presenting visual acuity (VA), many studies have identified these errors as the primary cause of visual impairment.<sup>2,3</sup> Several studies have evaluated the prevalence of the refractive errors across the world.<sup>4-8</sup> Although studies conducted on students signify the role of these errors, the highest prevalence has been observed in individuals above 40 years of age.<sup>9-13</sup> The prevalence of myopia shows a great variation from 51% in Myanmar<sup>6</sup> to 15% in the Blue Mountain study.<sup>7</sup> The prevalence of hyperopia also varies from 63.8% in the residents of Tehran who were at least 56 years old<sup>14</sup> to 1.6% in Chinese people.<sup>4</sup> The prevalence of astigmatism has also been reported up to 74% in Taiwan.<sup>15</sup> The review of the literature shows that in most parts of the world in individuals above 40 years of age, at least one out of every two persons suffers from myopia, hyperopia or astigmatism. Regarding public health, it seems that these conditions impose a high burden in different countries. The direct costs of these errors, which include correction by glasses, refractive surgeries, and lens implantation, are high for societies with a high percentage of the afflicted individuals. On the other hand, refractive errors impose indirect costs on individuals and governments through home or road accidents.

Despite the fact that many papers have been published on refractive errors in well-known journals every year, it seems that our information on the global distribution of these conditions is not yet sufficient and therefore more epidemiologic studies are required.

Regarding myopia, we already know that East Asian countries are afflicted with this anomaly in an epidemic fashion but our information about hyperopia and astigmatism is much less.<sup>15-18</sup>

Up to now, two studies have evaluated the prevalence of myopia, hyperopia and astigmatism in the elderly population of Iran.<sup>14,19</sup> In these two studies, although myopia was found in less than 30% of the individuals above the age of 55, at least 50% were hyperopic and about 80% of the participants aged 55 or higher were either myopic or hyperopic.

These studies, along with a number of studies on Iranian students, suggest that the prevalence of hyperopia in Iran is high and therefore further studies should be conducted to elucidate the role of factors such as genetics,<sup>9</sup> race, and even environment.

For the aforementioned reasons, we conducted this cross-sectional study in Sari (the center of Mazandaran province in north of Iran) which has a different ethnicity as compared to previous study sites, to evaluate the prevalence of the refractive errors in individuals aged 55 or more.

## Methods

### Population and samples

This cross-sectional study was conducted between September 2010 and July 2011. The target population of this study was the 55-year-old and over population of Sari. The population of Sari was 273,972 based on the report of the last census in 2007. Of this population, 29,118 were 55 years old and over.

The sample size was calculated using the Tehran Eye Study<sup>14</sup> in which the prevalence rates of hyperopia and myopia based on non-cycloplegic refraction in 56-year-old and over were 58.6% and 23%, respectively. In the present study, the sample size was calculated for an estimated refractive error prevalence of 75%, a precision of 3%, and 95% confidence interval (CI) ( $Z_{1-\alpha/2}=1.96$ ). Considering a design effect of 1.25 and non-response rate of 10%, the total sample size was calculated as 1,100. The target population of this study was the 55-year-old and over inhabitants of the district one of Sari who were selected through randomized cluster sampling using the information available at the district health centers. Available information of the medical records of the individuals were used to invite them to participate in the study via telephone.

Sixty clusters were randomly selected in this district and from each cluster, 20 individuals were systematically selected. In each cluster, the first household was randomly selected and then, every other eligible household was invited to join the study by the health volunteers. Upon invitation, each household was briefed on the importance of this study and an appointment was arranged

for examinations for all individuals aged 55 and above in the household. The team proceeded to the next household if no one answered in a household and the household was again contacted later. Also, the team approached the next household if there was no one above 55 years of age in a household.

After selecting 20 samples in each cluster, the team proceeded to the next cluster.

After participation, a questionnaire including information on age, gender, type and duration of the present and past systemic or ocular disease(s), history of ocular surgery, family history and drug history was completed by each participant.

### **Examinations**

To measure habitual VA and optimal VA, the Snellen chart was used at 4 m under standard light conditions (80 and 320 cd/m<sup>2</sup>). Further examinations included the examination of the eyelids, sclera, cornea, tear layer, iris and lens with a slit-lamp, pupil reflex, visual field testing, fundoscopy and tonometry. These examinations were performed by an ophthalmologist after optometric examinations.

Lens opacities were graded according to the lens opacities grading system III (LOCS III). Nuclear cataract was defined as nuclear opacity grade 4 and over, and the diagnosis of cortical and posterior subcapsular cataracts was based on cortical and posterior subcapsular opacity grade 2 and over.

### **Refractive errors measurements**

After performing the above-mentioned examination, refractive errors were measured with an autorefractometer (Topcon RM 8800) for five times and the mean value was documented; then, manual retinoscopy was performed to check the results. If the pupil was small, there was media opacity or the reflex was dull, radical retinoscopy was done at a closer than standard distance to check the results of the autorefractometer. The addition power was determined using the near Snellen chart. Then, monocular and binocular subjective refraction was performed and optimal VA was recorded.

### **Definitions**

Spherical equivalent (SE) was used to evaluate spherical refractive errors. Similar to

most previous studies, myopia was defined as an SE less than -0.5 D, hyperopia was defined as an SE more than 0.5 D and astigmatism was defined as cylinder power more than 0.5 D. Anisometropia was present when the difference of the SE of the two eyes was at least 1 D.

The axis between 0°-30° or 150°-180° was considered with-the-rule (WTR) and the axis between 60°-120° was considered against-the-rule (ATR) astigmatism; other values were recorded as oblique astigmatism. Similar to other studies,<sup>14,19</sup> severe myopia was defined as SE less than -6 D, moderate myopia as SE between -6 D and -3.1 D and mild myopia as SE between -3 D and -0.51 D. Severe, moderate, and mild hyperopia were defined as SE more than 4 D, 2.1 D to 4 D, and 0.5 D to 2.1 D, respectively.

### **Exclusion criteria**

In this report, only data from phakic eyes were included for analysis, and those who had any history of eye surgery were excluded.

### **Statistical analysis**

The prevalence of the different refractive errors was reported as percentage with a 95% CI. All prevalences were standardized for age and gender distribution of the Sari population in 2007. Multiple logistic regression was employed to evaluate the correlation of the risk factors with refractive errors and the odds ratio was calculated.

### **Ethical issues**

Each individual signed an informed consent form prior to participation, after receiving information on the objective of the study. Before examinations were conducted, the Ethics Committee of Vice Chancellor for Research of Mashhad University of Medical Sciences approved the study protocol.

### **Results**

Of 1185 individuals who were selected through sampling for this study, 937 participated (response rate: 79.1%) with a mean age of 64.7±7.5 years (range, 55-87). Of all the participants, 53.6% were female, 31.2% were 55-59 years, 21.8% were 60-64 years, 19.3% were 65-69 years, 14.3% were 70-74 years and 13.4% were 75 and older. The mean SE of the participants was

0.25±2.0D (from -9 to 11 D). Figure 1 shows SE in different age groups in male and female participants.

### Myopia

The prevalence of myopia in our study was 20.2% (95% CI 17.6-22.7%). Myopic individuals had a mean SE of -2.28±1.89 D. Mild, moderate, and severe myopia was observed in 15.7%, 3%, and 1.5% of the study population, respectively. Table 1 presents the prevalence of myopia according to age and gender. As this Table indicates, myopia was more prevalent in men than women; logistic regression showed that the odds of myopia were 1.42 times more in men as compared to women (95% CI 1.03-1.95,  $p=0.031$ ). According to the results of logistic regression and age-categorized analysis adjusted with gender, it was noted that myopia was

significantly more prevalent in 65 to 69-year-old participants when compared to participants aged 55-59 ( $p=0.033$ ) and that the odds of myopia were 49% less in participants aged 70-74 when compared to 55 to 59-year-old subjects ( $p=0.031$ ). The prevalence of myopia was 31.8% and 15.3% in cataract and non-cataract participants respectively; the odds of myopia were 2.6 times greater in cataract vs. non-cataract participants ( $p<0.001$ ). Evaluation of the relationship of the myopia with age, gender and cataract in a multiple logistic regression model showed that myopia was significantly less prevalent in individuals above the age of 70 years when compared to participants aged 55-59, was more prevalent in men with its odds being 2.8 times greater in cataract vs. non-cataract subjects.

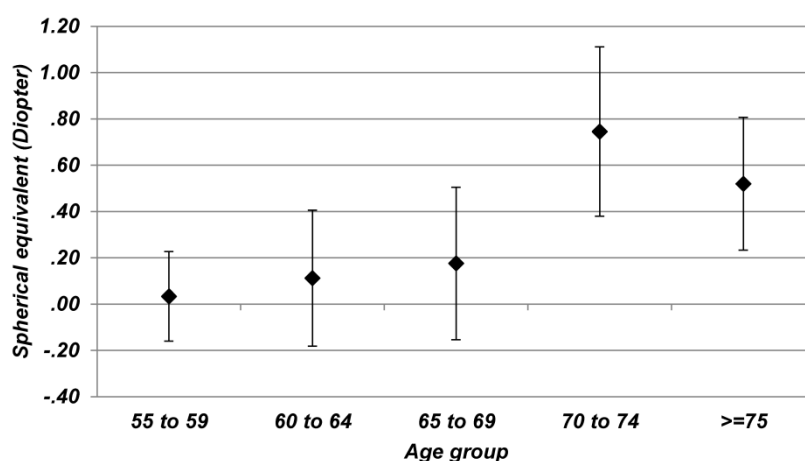


Figure 1. Spherical equivalent in different age groups

Table 1. Prevalence of myopia, hyperopia, astigmatism, anisometropia and one type of ametropia by age and gender

Age (year)	Myopia	Hyperopia	Astigmatism	Anisometropia	Ametropia
Age	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
55 to 59	20.2 (15.6-24.8)	29.5 (24.2-34.7)	28.8 (23.5-34.0)	5.1 (2.6-7.7)	55.8 (50.1-61.6)
60 to 64	21.1 (15.4-26.7)	39.2 (32.5-46.0)	26.5 (20.4-32.6)	11.8 (7.3-16.2)	62.7 (56.1-69.4)
65 to 69	28.7 (22.1-35.4)	35.4 (28.3-42.4)	21.0 (15.0-27.0)	10.5 (6.0-15)	70.7 (64.0-77.4)
70 to 74	11.9 (6.4-17.5)	47.8 (39.2-56.3)	20.1 (13.3-27.0)	8.2 (3.5-12.9)	64.9 (56.7-73.1)
>=75	15.1 (8.7-21.4)	52.4 (43.5-61.2)	18.3 (11.4-25.1)	6.3 (2.0-10.7)	71.4 (63.4-79.4)
Male	23.2 (19.2-27.2)	34.0 (29.6-38.5)	24.6 (20.5-28.7)	8.7 (6.1-11.4)	62.1 (57.5-66.6)
Female	17.5 (14.2-20.9)	42.2 (37.9-46.6)	23.7 (20.0-27.4)	7.8 (5.4-10.1)	64.9 (60.8-69.1)
Total	20.2 (17.6-22.7)	38.4 (35.3-41.5)	24.1 (21.4-26.9)	8.2 (6.5-10.0)	63.1 (60.5-66.6)
Age sex standardized	19.7 (17.0-22.4)	39.5 (36.1-42.9)	23.6 (20.7-26.4)	7.8 (6.0-9.6)	64.0 (60.7-67.3)

CI: confidence interval

**Hyperopia**

About 38.5% of the subjects were hyperopic (95% CI 35.3-41.5) with a mean SE of  $1.8 \pm 1.6$ D. Mild, moderate, and severe hyperopia was observed in 29.7%, 6.2%, and 2.6% of the participants, respectively. According to table 1, hyperopia increased significantly with age (each one year increase in age increased the odds of hyperopia by 4%) ( $p < 0.001$ ). Moreover, the odds of hyperopia were 1.41 times more in women as compared to men ( $p = 0.010$ ); this association was still observed after adjustment for age and gender.

**Astigmatism**

The prevalence of astigmatism more than 0.5 D was found to be 24.1% (95% CI 21.4-26.9) in this study and it was noted that the prevalence decreased with age (OR=0.97, 95% CI 0.95-0.99) but no difference was observed between men and women ( $p = 0.750$ ). The prevalence of astigmatism was 38.3% in cataract vs. 18.2% in non-cataract participants ( $p < 0.001$ ). Analysis of age, gender and cataract with multiple logistic regression showed the significant correlation of astigmatism prevalence with age and cataract. WTR, ATR, and oblique astigmatism were seen in 7.5%, 13.1%, and 3.5% of the study population, respectively. In other words, 31.0%, 54.4% and 14.6% of the astigmatic participants had WTR, ATR, and oblique astigmatism, respectively.  $\chi^2$  showed a significant difference in the type of astigmatism between the two genders ( $p = 0.046$ ); WTR and ATR astigmatism were more prevalent in men and women respectively. Of astigmatic men, 37.4%, 45.8%, and 16.8% had WTR, ATR, and oblique astigmatism while 25.2%, 62.2%, and 12.6% of the astigmatic women had the aforementioned conditions, respectively. No significant difference was found in the type of astigmatism among age groups ( $p = 0.171$ ).

**Anisometropia**

The prevalence of anisometropia in the present study was 8.2% (95% CI 6.5-10.0); it did not show any correlation with age ( $p = 0.743$ ) or gender (0.591). However, the odds of anisometropia were 3.8 times greater in cataract vs. non-cataract ( $p < 0.001$ ) and 6.6 times greater in myopic vs. non-myopic

participants ( $p < 0.001$ ). The prevalence of anisometropia was significantly higher in participants who suffered from amblyopia and strabismus ( $p < 0.001$ ). Analysis of the correlation of age, gender, cataract, amblyopia, strabismus and myopia with anisometropia using multiple logistic regression showed that amblyopia, strabismus and cataract correlated with anisometropia significantly.

**Ametropia**

The prevalence of at least one type of ametropia was 64.0% in the participants (95% CI 60.7-67.3), 62.1% in men and 64.9% in women ( $p = 0.361$ ). The prevalence of ametropia was 55.8% in the age group 55-59 and increased significantly with age to reach 71.4% in participants aged 75 years and above ( $p < 0.001$ ). The odds of ametropia were significantly greater in cataract vs. non-cataract participants (OR=3.0, 95% CI 2.2-4.2).

**Discussion**

The present study was the second study that exclusively evaluated refractive errors in individuals age 55 years and above in an Iranian population. In this study, in addition to the prevalence of myopia, hyperopia and astigmatism, the percentage of the ametropic individuals, who had at least one type of the refractive errors, was determined.

As mentioned earlier, 20.2% of the participants were myopic in this study as compared to 27.2% and 23% reported in Mashhad and Tehran studies.<sup>14,19</sup>

Table 2 shows that the prevalence of myopia ranges from 17% to 48% in different studies. According to this table, the highest prevalence is observed in East Asian countries like China, Taiwan, Japan and Singapore. It seems that one reason for the lower prevalence of myopia in this study, compared to previous studies conducted in Iran, is our definition of myopia (SE more than -0.5 D) while those studies defined myopia as SE equal to or more than -0.5 D. However, our findings, along with the findings of previous studies conducted in Iran, suggest that myopia is not the major concern in the Iranian elderly population. Our findings showed that myopia significantly correlated

with gender and cataract; this correlation has also been confirmed by several studies.<sup>19,20</sup> Regarding the higher prevalence of myopia in men, the reason seems to be the difference in the biometrical structure of the eye between men and women. Previous studies have shown that men have a longer axial length than women which seems to be the most important factor for the higher prevalence of myopia in men.<sup>21-24</sup>

Regarding cataract, its correlation with myopia has a high repeatability; this is specially true for nuclear cataract and myopia due to the lens index changes in nuclear cataract.<sup>25,26</sup>

The prevalence of hyperopia in our study was unexpectedly lower than Tehran and Mashhad studies but was very similar to the prevalence of myopia in East Asian countries which seems to be due to differences in ethnic and genetic factors between the residents of Sari and the inhabitants of Tehran and Mashhad (Table 2).

As mentioned earlier, hyperopia was more prevalent in women than men; this finding was expected since the axial length is shorter in women.<sup>27</sup> Unlike myopia, we noted that the prevalence of hyperopia underwent a great deal of change with age as the highest prevalence of hyperopia was observed in the elderly population. This finding is in line with the findings of the previous studies and the only strong hypothesis in this regard in the lens structural changes in old ages, specially presbyopia, which is probably responsible for the majority of hyperopic cases in the elderly population.<sup>28,29</sup>

Astigmatism had a relatively low prevalence in our study in comparison with Mashhad and Shahroud studies; although less than 25% of the participants in our study were astigmatic, it is reported to affect more than 50% of the people in some parts of the world such as Taiwan, Indonesia, India and Japan (Table 2). From previous studies, we already know that race-related factors are one of the reasons of the difference in the prevalence of astigmatism worldwide; however, the lower prevalence of astigmatism in our study, as compared to Mashhad and Shahroud studies, was unexpected.<sup>14,19,30</sup> The ethnic differences could be responsible for this difference.<sup>30</sup> It seems that changes in the surface of the cornea caused by the dry climate and rubbing

of the eyes may result in corneal surface irregularity, resulting in astigmatism.<sup>31</sup>

In our study, 31.0%, 54.4%, and 14.6% of the astigmatic individuals had WTR, ATR, and oblique astigmatism, respectively. Although different studies employ different definitions of the astigmatism axis, the most common type of astigmatism is ATR in most studies, including ours. For example, 54.5%, 58.7%, 62.5% and 77.4% of the astigmatic individuals from Singapore,<sup>17</sup> Bangladesh,<sup>20</sup> Taiwan<sup>15</sup> and India<sup>32</sup> have ATR astigmatism. Unlike most studies, we found no significant correlation between age and astigmatism type which seems to be due to the fact that most of our participants were elderly individuals; however, the high prevalence of ATR astigmatism in the elderly is a common finding in most studies. Some studies have even suggested the role of decreased eyelid pressure in increasing the prevalence of ATR astigmatism with age.<sup>33,34</sup> Available data on the type of astigmatism and gender shows that the type of astigmatism is probably affected by race since in our study and in Shahroud study,<sup>35</sup> women mostly had ATR astigmatism while studies conducted by Mandel et al<sup>36</sup> Huynh et al,<sup>37</sup> have reported higher prevalence of WTR astigmatism in women.

The prevalence of anisometropia was 8.2% in our study which did not differ significantly with 10.7% reported in the elderly population of Mashhad and is relatively low as compared to other studies conducted worldwide;<sup>19</sup> for example, the prevalence of anisometropia in individuals aged 40 and above has been reported to be 35.3% in Myanmar,<sup>38</sup> 15.9% in Singapore<sup>18</sup> and 14.7% in the Blue Mountains studies.<sup>39</sup> Also, it should be mentioned that its prevalence is reported to be 1.6% in Australian<sup>40</sup> individuals aged 55-82. Of factors related to anisometropia in our study, myopia and cataract have been reported in previous studies as well. Since cataract affects each eye independent of the other eye and the degree of cataract is not similar in both eyes, the two eyes have different lens refractive changes, resulting in anisometropia. It is interesting that anisometropia, in this age group, showed a strong correlation with amblyopia. Several studies have reported that anisometropia is the primary cause of amblyopia<sup>41</sup>; it should of course be

remembered that anisometropia in the elderly may result from other reasons.

In this study, in addition to the prevalence of myopia, hyperopia and astigmatism, we determined the percentage of the ametropic individuals who had at least one type of the refractive errors. The prevalence of ametropia in this study provided us with valuable information from the view point of general health. Overall, 64% of our participants were ametropic; this value has been reported to be 70% or even more in individuals aged 75 and over.

Figure 2 shows the percentage of the participants who were either myopic or hyperopic. As this figure shows, this value was more than 80% in Tehran study and more than 70% in studies conducted in Singapore, Australia, the US, and Taiwan. Although ametropia in figure 2 is without inclusion of astigmatic cases, the prevalence of ametropia in our study, with inclusion of astigmatic cases, is not high as compared to those reports.

It is very important to pay special attention to ametropia in the old age. According to our

study and many other reports, a high percentage of the elderly people suffer from at least one type of refractive errors. It should also be remembered that most of them develop presbyopia and the combination of presbyopia and a refractive error, specially hyperopia, often results in a worse visual condition.

The present study had some limitations - like not using cycloplegic refraction and existence of other ocular diseases due to the old age of the participants - which makes it almost impossible to have a definite conclusion about the status of refractive errors in this age group. Moreover, due to the fact that participants were not from different races and ethnicities, its findings cannot be generalized to the whole Iranian population and are only true for a limited region in the north of Iran.

This study provided valuable information on the prevalence of refractive errors in an elderly population residing in the north of Iran. According to the findings of this study, a great proportion of the elderly had at least one type of refractive errors in addition to presbyopia.

**Table 2.** Prevalence of the refractive errors in different studies

	Age	Myopia (%)	Hyperopia (%)	Astigmatism
Myanmar <sup>6</sup>	≥40	51.0	15	30.6
Japan <sup>42</sup>	≥40	41.8	8.2	54.0
Hong Kong <sup>43</sup>	>40	40.0	-	-
Indonesia <sup>44</sup>	>40	48.5	13.9	77
Sari, Iran (This study)	55-87	20.2	38.4	24.1
Singapore <sup>18</sup>	40-79	35.0	35.9	37.8
India <sup>27</sup>	>40	34.6	18.4	37.6
Singapore <sup>17</sup>	40-80	30.7	27.4	39.4
Mashhad, Iran <sup>19</sup>	≥55	27.2	51.6	37.5
India <sup>45</sup>	>39	27.0	18.7	-
USA (Beaver Dam) <sup>8</sup>	43 to 84	26.2	49	-
China <sup>46</sup>	40-90	22.9	20	-
Tehran, Iran <sup>14</sup>	>56	23	58.6	-
Bangladesh <sup>20</sup>	≥30	22.1	20.6	34.2
USA (Barbados) <sup>47</sup>	40-84	21.9	46.9	32.4
Taiwan <sup>15</sup>	≥65	19.4	59	74
China <sup>15</sup>	40-79	19.4	1.6	24.5
Mongolia <sup>48</sup>	≥40	17.2	32.9	49.4
Australia (Victoria) <sup>49</sup>	≥40	17.0	18	-
Australia (Blue Mountains) <sup>7</sup>	49-97	15.0	57	37

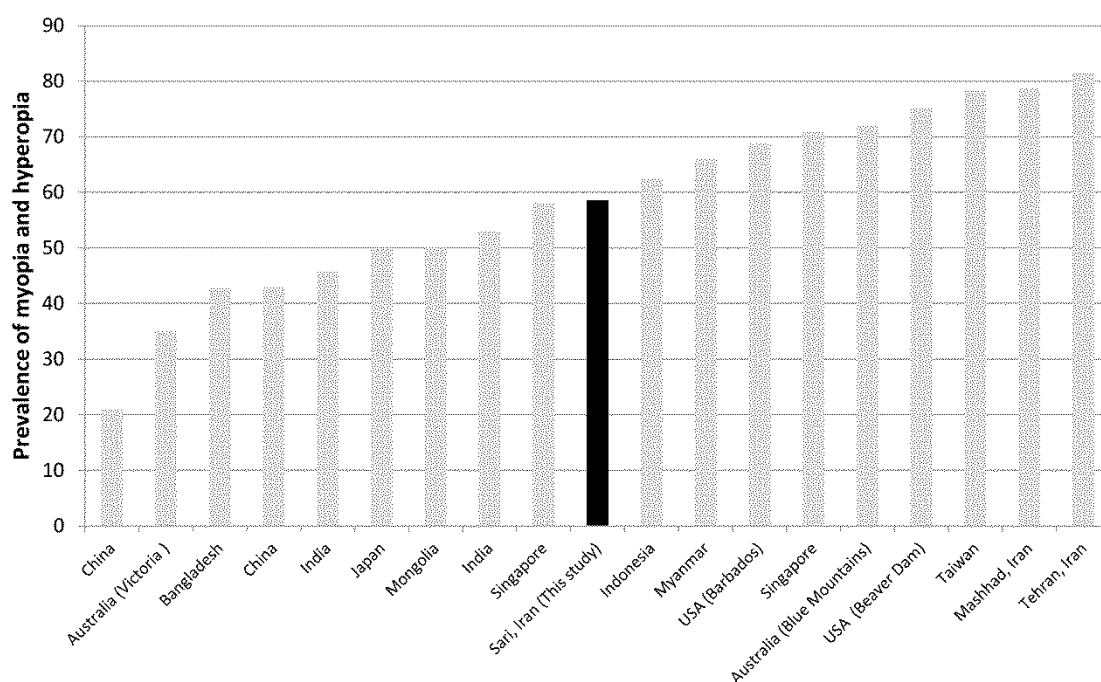


Figure 2. Prevalence of ametropia in different studies by hyperopia or myopia

## Conclusion

The prevalence of myopia in this study was lower than East Asian countries but similar to previous reports from Iran. We noted that hyperopia was the major problem in our study population. Since the combination of presbyopia and hyperopia results in an undesirable visual condition in the elderly, it is important to pay proper attention to visual

problems in this age group.

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