Prevalence of hyperopia in school-aged children in eastern Mediterranean region: A systematic review and meta-analysis

Saif H. Alrasheed[1,2], Naveen K. Challa[1]

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Abstract:

PURPOSE: This systematic review and meta-analysis aimed to provide the available data on the prevalence of childhood hyperopia in the eastern Mediterranean region (EMR).

METHODS: The study used preferred reporting items for systematic reviews and meta-analyses, 2020. The articles were searched in six online databases (Web of Sciences, Scopus, Index Medicus for the EMR, ProQuest, PubMed, and Medline). For studies published on the prevalence of hyperopia in the EMR from January 2000 to May 2022. The reviewed data were grouped by age, gender, and refractive measurement technique, hyperopia was defined as refractive error ≥2.00 diopter.

RESULTS: The final meta-analysis contained 27 quality-assessed studies from 12 countries, covering 51, 987 children. The overall pooled prevalence of childhood hyperopia from 2000 to 2022 is 6.33% in EMR. The hyperopia prevalence was slightly higher among females at 4.34%, compared to males at 4.21%. The prevalence of hyperopia in younger children (5–10 years) was higher at 5.72%, and lower in older aged (11–17) years at 3.23%; $P = 0.001$. Furthermore, there was a higher hyperopia prevalence with cycloplegic refraction at 7.35% compared with noncycloplegic refraction at 3.93%. There was highly significant heterogeneity between the studies ($P < 0.0001$).

CONCLUSION: The prevalence of hyperopia among children in the EMR was high compared to other regions, particularly in younger children. More studies are required using standardized methods in different regions where there is a lack of information on hyperopia prevalence. Early interventions are essential to be implemented in the EMR to protect future adults from the development of strabismus and amblyopia.

Keywords:

Childhood hyperopia, eastern Mediterranean region, hyperopia, refractive error, visual impairment

Introduction

Uncorrected refractive error is the major cause of childhood visual impairment globally and is common in underdeveloped nations.[1,2] Recent global estimates showed that approximately 19 million children aged 5–15 years were visually impaired due to refractive error and 90% of them live in developing countries.[3,4] A previously published study of the regional and global prevalence of hyperopia among children found that the pooled prevalence estimates of hyperopia (spherical equivalent ≥+2.00 diopters) were 4.6%.[5] Hyperopia is the most common refractive error among children, moderate-to-high degrees are associated with a risk for the development of strabismus and amblyopia.[1,2] The condition commonly affects near activity and optimal vision is a critical component of a child's learning and education.[6] Early studies showed that uncorrected hyperopia affected a child's social interaction, academic achievement, and economic productivity.[7-9]

In developed countries, school vision screening programs are quite common where they have been effectively combined into educational systems and childhood health care, but in developing countries, this childhood eye care plan is rarely implemented.[10] Whereas, such vision screening plans depend on the assessment of distance visual acuity hence, are biased to detect

[1]Department of Optometry, College of Applied Medical Sciences, Qassim University, Buraydah, Saudi Arabia, [2]Department of Binocular Vision, Faculty of Optometry and Visual Sciences, Al-Neelain University, Khartoum, Sudan

Address for correspondence:
Dr. Saif H. Alrasheed, Department of Optometry, College of Applied Medical Sciences, Qassim University, Buraydah, Saudi Arabia.
E-mail: s.rasheed@qu.edu.sa

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myopia, astigmatism, and amblyopic risk factors.[11,12] Author from previous study[13] reported that the detection and correction of childhood hyperopia could be crucial for successful reading and writing, however, it is commonly ignored. Kulp *et al*.[14] reported difficulties in children with hyperopia 4.0 D or worse and hyperopia +3.0D to +6.0D commonly associated with reduced visual acuity. Moreover, small degrees of hyperopia in children are observed as relatively benign, as it is likely that children have sufficient accommodation amplitude to overcome it.[15]

Grosvenor[16] reported that the eye care professionals focus on the studies in prevention and control of myopia and hyperopia was ignored and did not obtain consideration as myopia. He indicated that the in the *American Journal of Optometry* the cumulative index includes many references to myopia in treatment and prevention, whereas only a few references to hyperopia. He emphases that hyperopia causes many eye problems that are not shared by any other refractive error, and that this is due to high accommodative amplitude in children, making it difficult to detect during a visual acuity screening test. Furthermore, the excessive accommodation required to obtain a clear retinal image resulted in accommodative convergence, which could lead to convergence strabismus and amblyopia. Therefore, this systematic review and meta-analysis aimed to assess the prevalence of hyperopia in school-aged children concerning age, gender, and methods of assessment in the eastern Mediterranean region (EMR).

Methods

This study used the framework of the preferred reporting items for systematic reviews and meta-analyses, 2020 methods as shown in Figure 1.[17]

Search plan and quality assessment of studies

The authors conducted a systematic search and review for studies performed to assess the prevalence of hyperopia among children in the EMR between January 2000 and May 2022. The quality of each study was evaluated using the worksheet developed by Downs and Black, whereas each selected article was assessed and scored on a 10-item scale, as shown in Table 1.[18] This review was restricted to articles published in English, available online, peer-reviewed journal articles, and mentioning the prevalence of hyperopia among children in the EMR. The articles included in this systematic review and meta-analyses were searched in six online databases (Web of Sciences, Scopus, Index Medicus for the EMR, ProQuest, PubMed, and Medline). For studies published on the prevalence of hyperopia in school-aged children in the EMR from January 2000 to May 2022. In this systemic review and meta-analysis, the search keywords were conducted using the Boolean operator (OR/AND): The search keywords such as (prevalence OR rate OR incidence OR frequency OR proportion OR distribution OR epidemiology) AND hyperopia in school-aged children in EMR. In addition, for several repetitions of these search terms used AND/OR in the EMR, which included 21 countries (Afghanistan, Bahrain, Djibouti, Egypt, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, and the United Arab Emirates).

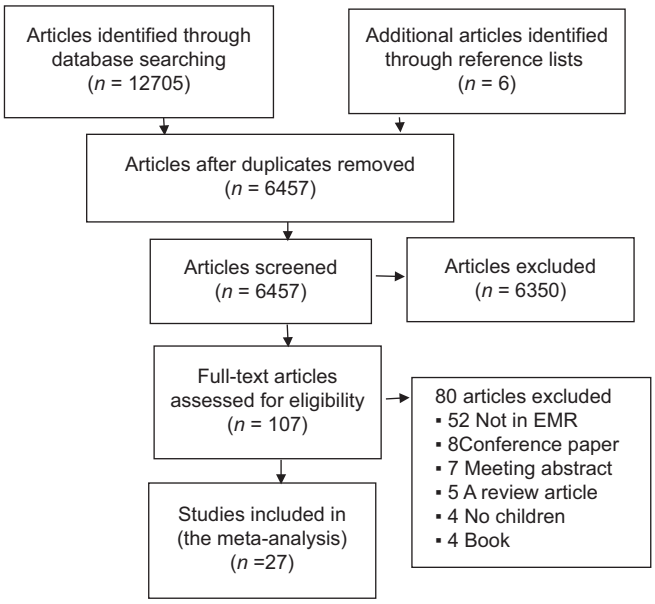

Figure 1: PRISMA flow diagram template for systematic reviews used in this study. PRISMA: Preferred reporting items for systematic reviews and meta-analyses

Inclusion and exclusion criteria

Articles published between January 2000 and May 2022, assessing the prevalence of hyperopia in male and female school children aged 5–17 years were included in the study. Epidemiological Studies used an observational cross-sectional study design; had a clear description of the method used in data collection such as the sampling method; reported the technique used for measuring refractive error (cycloplegic or noncycloplegic refraction) in addition to objective or subjective refraction; mention the benchmarks for defining hyperopia as spherical equivalent ≥2.00 D of hyperopia. However, the review excluded editorial discussions, conference papers, meeting abstracts, and articles without basic data gathering and retrospective hospital-based studies.

Data extraction

The title and abstract of each selected article were carefully assessed by the author, and data such as the first author's name, year of publication; study country; subject's characteristics (age and sample size); the technique of refractive error measurement (cycloplegic or noncycloplegic); benchmarks for defining hyperopia; in addition to the prevalence of hyperopia were extracted as shown in Table 1.

Data analysis

Meta-analysis was conducted using MedCalc-Version 19.6.1 (MedCalc Software, Mariakerke, Belgium) software. The study data were entered individually from a predesigned format that recorded the information about the author's name, date of

Table 1: Characteristics of studies reporting the prevalence of childhood hyperopia across the Eastern Mediterranean Region (2000–2022)

Author and year of study	Country	Age group (years)	Age (mean±SD)	Sample size	Cycloplegia	Refraction assessment	Prevalence of hyperopia (%)	Quality assessment score
Abbas *et al*., 2019[19]	Pakistan	6–14	10.1±1.8	6192	No	Objective	8.9	8
Yamamah *et al*., 2015[20]	Egypt	6–17	10.7±3.1	2070	Yes	Objective	3.62	10
Alrasheed *et al*., 2016[21]	Sudan	6–15	10.8±2.8	1678	Yes	Objective	1.9	10
Abdi Ahmed *et al*., 2020[22]	Somalia	6–15	11.2±2.5	1204	No	Objective	2.7	10
Al Wadaani *et al*., 2013[23]	Saudi Arabia	6–15	9.4±2.3	2002	Yes	Objective	1.4	10
Aldebasi, 2014[24]	Saudi Arabia	6–13	9.5±1.8	5176	Yes	Objective	0.7	10
Yekta *et al*., 2010[25]	Iran	7–15	10.9±2.3	1872	Yes	Objective	5.04	9
Ullah *et al*., 2020[26]	Pakistan	5–12	8.1±2.3	2288	No	Objective	2.0	8
Rezvan *et al*., 2012[27]	Iran	6–17	11.2±2.4	1551	Yes	Objective	5.4	9
Mohamed *et al*., 2017[28]	Sudan	5–15	12.41±1.9	822	No	Objective	1.1	8
Jamali *et al*., 2009[29]	Iran	6	-	902	Yes	Objective	20.5	9
Hameed, 2016[30]	Pakistan	5–15	-	1644	No	Objective	1.28	8
Fotouhi *et al*., 2007[31]	Iran	7–15	-	5544	Yes	Objective	16.5	10
Elmajri, 2017[32]	Libya	7–11	9.5±1.5	920	Yes	Objective	6.2	7
Alrahili *et al*., 2017[33]	Saudi Arabia	5–10	-	1893	No	Objective	1.5	9
Alghamdi, 2020[34]	Saudi Arabia	6–13	9.2±1.9	417	No	Objective	9.11	10
Gilal *et al*., 2022[35]	Pakistan	6–15		400	Yes	Objective	3.5	8
Bataineh and Khatatbeh, 2008[36]	Jordan	12–17	13.2±2.1	1647	Yes	Objective	2.85	8
Ostadi Moghaddam *et al*., 2008[37]	Iran	6–17	11.2±2.6	2132	No	Objective	8.4	9
Al-Rowaily, 2010[38]	Saudi Arabia	5–8	-	1319	No	Objective	2.1	9
Fotouhi *et al*., 2011[39]	Iran	8–14	10.7±2.3	2957	Yes	Objective	10.1	10
Hashemi *et al*., 2016[40]	Iran	7	-	4072	Yes	Objective	6.2	8
Hashemi *et al*., 2018[41]	Iran	5–15	10.0±3.2	602	Yes	Objective	4	10
Hussam Uldeen Hatow *et al*., 2018[42]	Iraq	6–8	6.1±0.34	735	Yes	Objective	20.1	8
Kandi and Khan, 2021[43]	UAE	6–10	-	733	Yes	Objective	2.2	9
Al Nuaimi *et al*., 2010[44]	Qatar	5–15	-	670	No	Objective	5.4	8
Anera *et al*., 2009[45]	Morocco	6–16	-	545	Yes	Objective	18.3	9
All			10.52±1.63	51,987			6.33	

SD: Standard deviation

publication, the nation of study, mean age, sample size, the method for assessment of refraction, and the prevalence of childhood hyperopia. Heterogeneity among studies was assessed using *a Q*-statistic that is distributed as Chi-square under the assumption of homogeneity of effect sizes and *I2* index *I2* values ranged between 0% and 75%, which represented none to high heterogeneity. MedCalc-Version 19.6.1 was used to create tables that presented the prevalence of hyperopia among children, by age, gender, and refraction method in different studies and the corresponding weight for each study. The overall pooled prevalence of childhood hyperopia was estimated using a random-effect model and its associated 95% confidence intervals (CI). $P < 0.05$ were statistically significant. The potential bias for selected studies such as small/large study effects was assessed and shown in tables. Furthermore, the prevalence of hyperopia in children was divided into separate datasets regarding overall prevalence, cycloplegic or noncycloplegic, males or females, and age.

Results

Study characteristics

The authors identified 12,705 articles, as shown in Figure 1. After removing duplicate articles, we reviewed the titles of 6457 articles. Then, we excluded 6350 articles after reading their abstracts because they did not meet the inclusion criteria, and we excluded 80 articles after reading their full texts because the required information could not be extracted. The final meta-analysis included 27 quality-assessed studies from 12 countries [Table 1]. Publication years were 2007–2022, and the overall sample size of the studies was 51,987 children with a mean age of 10.52 ± 1.63 years.

Prevalence of childhood hyperopia in eastern Mediterranean region (2000–2022)

A meta-analysis of hyperopia prevalence among children aged 5–17 years in the EMR is shown in Table 2. The overall pooled prevalence of hyperopia in the EMR was (6.33%, 95% CI: 4.00–8.00; $P < 0.001$), and almost 29.63% of reviewed studies ($n = 8$) reported a significantly higher prevalence of hyperopia and 44.44% ($n = 12$) reporting lower prevalence compared with the pooled estimate across EMR. The study conducted by Jamali *et al*. 2009[29] reported the highest prevalence of hyperopia 20.5% among Iranian children (95% CI: 18.00–23.00), whereas Aldebasi 2014[24] reported the lowest prevalence of 0.70%, among Saudi children (95% CI: 0.00–1.00). The pooled prevalence estimates of hyperopia in this review were similar to the study by Hashemi *et al*. in 2016[40] (6.2%, 95% CI: 5.00–7.00) among Iranian children.

Table 2: Prevalence of childhood hyperopia in Eastern Mediterranean Region (2000–2022)

Authors (years)	Country	Prevalence (95% CI)	Weight (%)
Abbas *et al*., 2019[19]	Pakistan	8.9 (8.00–10.00)	1.48
Yamamah *et al*., 2015[20]	Egypt	3.62 (2.00–4.00)	3.32
Alrasheed *et al*., 2016[21]	Sudan	1.9 (1.00–2.00)	4.45
Abdi Ahmed *et al*., 2020[22]	Somalia	2.7 (2.00–4.00)	2.24
Al Wadaani *et al*., 2013[23]	Saudi Arabia	1.4 (1.00–2.00)	7.23
Aldebasi, 2014[24]	Saudi Arabia	0.7 (0.00–1.00)	37.1
Yekta *et al*., 2010[25]	Iran	5.04 (4.00–6.00)	1.89
Ullah *et al*., 2020[26]	Pakistan	2.0 (1.00–3.00)	5.58
Rezvan *et al*., 2012[27]	Iran	5.4 (4.00–7.00)	1.46
Mohamed *et al*., 2017[28]	Sudan	1.1 (0.00–2.00)	3.65
Jamali *et al*., 2009[29]	Iran	20.5 (18.00–23.00)	0.27
Hameed, 2016[30]	Pakistan	1.28 (1.00–2.00)	6.27
Fotouhi *et al*., 2007[31]	Iran	16.5 (16.00–18.00)	1.93
Elmajri, 2017[32]	Libya	6.2 (5.00–5.00)	0.76
Alrahili *et al*., 2017[33]	Saudi Arabia	1.5 (1.00–2.00)	6.03
Alghamdi, 2020[34]	Saudi Arabia	9.11 (6.00–12.00)	0.24
Gilal *et al*., 2022[35]	Pakistan	3.5 (2.00–5.00)	0.57
Bataineh and Khatatbeh, 2008[36]	Jordan	2.85 (2.00–5.00)	2.86
Ostadi Moghaddam *et al*., 2008[37]	Iran	8.4 (7.00–10.00)	1.33
Al-Rowaily, 2010[38]	Saudi Arabia	2.1 (1.00–3.00)	3.05
Fotouhi *et al*., 2011[39]	Iran	10.1 (9.00–11.00)	1.56
Hashemi *et al*., 2016[40]	Iran	6.2 (5.00–7.00)	3.36
Hashemi *et al*., 2018[41]	Iran	4.0 (2.00–6.00)	0.76
Hussam Uldeen Hatow *et al*., 2018[42]	Iraq	20.1 (17.00–23.00)	0.22
Kandi and Khan, 2021[43]	United Arab Emirates	2.2 (1.00–3.00)	1.65
Al Nuaimi *et al*., 2010[44]	Qatar	5.4 (4.00–7.00)	0.63
Anera *et al*., 2009[45]	Morocco	18.3 (15.00–22.00)	0.17
All		6.33 (4.00–8.00)	100.00
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		98.80	

CI: Confidence interval

The prevalence of hyperopia by gender among children in the eastern Mediterranean region (2000–2022)

Table 3 shows the prevalence of hyperopia by sex among children in the EMR. The prevalence of hyperopia was highly significantly different between studies in both male and female children ($P < 0.001$), and the overall pooled prevalence of hyperopia was slightly high in females 4.34% (95% CI: 2.00–7.00), whereas the overall pooled prevalence in males was 4.21% (95% CI: 2.00–6.00). The prevalence of hyperopia in females was 4.34% was lower than the overall pooled estimation of 6.33%.

The prevalence of childhood hyperopia by age group in the eastern Mediterranean region (2000–2022)

The pooled prevalence of hyperopia among children aged 5–10 years and 11–17 years is shown in Table 4. The pooled estimated prevalence of hyperopia in school children aged 5–10 years and 11–17 years was higher (5.72%, 95% CI 2.00–9.00) and lower (3.23%, 95% CI 1.00–6.00) respectively the difference was highly significant $P = 0.001$. Regarding children aged 5–10 years, the highest prevalence of hyperopia was reported in Iranian children[29]20.51% (95% CI: 18.00–23.00) and Saudi children[34] 9.11% (95% CI: 6.00–12.00), whereas the study conducted by Aldebasi[24] among Saudi children in the Qassim region showed the lowest prevalence of hyperopia 0.61% (95% CI: 0.00, 1.00). On the other hand, hyperopia prevalence among older children aged 11–17 years, children in Iran[31] showed the highest prevalence of 13.4% (95% CI: 12.00–15.00), whereas, the lowest hyperopia prevalence was reported among Pakistani[30] children 0.41% (95% CI: 0.00–1.00).

Childhood hyperopia prevalence by refraction technique among school children in eastern Mediterranean region

Table 5 shows the pooled estimated prevalence of hyperopia among children in the EMR. The findings revealed that studies that used cycloplegic refraction reported a higher prevalence of hyperopia among school-aged children (7.35%, 95% CI: 4.00–10.00) compared with studies that used noncycloplegic refraction (3.93%, 95% CI: 2.00–6.00). Meta-analysis showed highly significant heterogeneity between both groups of studies that used cycloplegia and noncycloplegia $P < 0.001$ as shown in Table 5.

Discussion

The findings of this meta-analysis provided recent estimates of the childhood hyperopia prevalence in EMR using data from

Table 3: Childhood hyperopia prevalence by gender in Eastern Mediterranean Region (2000–2022)

Authors (years)	Country	Prevalence (95% CI)	Weight (%)
	Male children		
Yamamah *et al*., 2015[20]	Egypt	3.72 (3.00–5.00)	3.23
Alrasheed *et al*., 2016[21]	Sudan	1.81 (1.00–3.00)	5.14
Abdi Ahmed *et al*., 2020[22]	Somalia	2.58 (1.00–4.00)	2.90
Al Wadaani *et al*., 2013[23]	Saudi Arabia	1.45 (1.00–2.00)	7.90
Aldebasi, 2014[24]	Saudi Arabia	0.78 (0.00–1.00)	36.9
Ullah *et al*., 2020[26]	Pakistan	2.18 (1.00–3.00)	9.08
Rezvan *et al*., 2012[27]	Iran	4.35 (3.00–6.00)	1.71
Mohamed *et al*., 2017[28]	Sudan	1.09 (0.00–2.00)	8.41
Hameed, 2016[30]	Pakistan	1.68 (1.00–2.00)	6.37
Fotouhi *et al*., 2007[31]	Iran	16.1 (14.00–18.00)	1.32
Alrahili *et al*., 2017[33]	Saudi Arabia	2.32 (1.00–3.00)	4.62
Alghamdi, 2020[34]	Saudi Arabia	9.11 (6.00–12.00)	0.56
Fotouhi *et al*., 2011[39]	Iran	9.41 (8.00–11.00)	1.78
Hashemi. *et al*., 2016[40]	Iran	5.10 (4.00–6.00)	7.59
Hashemi *et al*., 2018[41]	Iran	2.72 (1.00–5.00)	1.23
Kandi and Khan, 2021[43]	United Arab Emirates	2.92 (1.00–5.00)	1.61
All		4.21 (2.00–6.00)	100
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		96.95	
	Female children		
Yamamah *et al*., 2015[20]	Egypt	3.52 (2.00–5.00)	3.01
Alrasheed *et al*., 2016[21]	Sudan	1.91 (1.00–3.00)	4.47
Abdi Ahmed *et al*., 2020[22]	Somalia	2.75 (1.00–4.00)	2.04
Al Wadaani *et al*., 2013[23]	Saudi Arabia	1.25 (1.00–2.00)	8.34
Aldebasi, 2014[24]	Saudi Arabia	0.58 (0.00–1.00)	45.3
Yekta *et al*., 2010[25]	Iran	4.14 (3.00–5.00)	2.19
Ullah *et al*., 2020[26]	Pakistan	1.66 (1.00–3.00)	3.31
Rezvan *et al*., 2012[27]	Iran	6.06 (5.00–8.00)	1.59
Hameed, 2016[30]	Pakistan	0.72 (0.00–1.00)	9.65
Fotouhi *et al*., 2007[31]	Iran	17.29 (16.00–19.00)	1.32
Alrahili *et al*., 2017[33]	Saudi Arabia	0.74 (0.00–1.00)	12.85
Fotouhi *et al*., 2011[39]	Iran	10.72 (9.00–12.00)	1.65
Hashemi *et al*., 2016[40]	Iran	7.40 (5.00–9.00)	1.02
Hashemi *et al*., 2018[41]	Iran	5.19 (3.00–8.00)	0.62
Kandi and Khan, 2021[43]	United Arab Emirates	1.24 (0.00–2.00)	2.62
All		4.34 (2.00–7.00)	100.00
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		99.11	

CI: Confidence interval

twenty-seven studies from twelve countries conducted from 2000 to 2022. The benchmarks for defining hyperopia used in this study as spherical equivalent are ≥2.00 D. The overall prevalence of childhood hyperopia across EMR countries was 6.33%, and there were vast differences within and between EMR countries. There was highly significant heterogeneity between the studies (P < 0.0001). The highest prevalence of hyperopia was found among Iranian[29] and Iraqi children,[42] whereas significantly lowest hyperopia prevalence was reported among Saudi children.[24] Conversely, Hashemi *et al*.[41] found that the prevalence of hyperopia in Iranian children is similar to the overall estimate.

Some countries, such as Saudi Arabia reported variation in the prevalence of childhood hyperopia at 9.11%,[34] 2.10%,[38] 1.50%,[33] and 0.7%.[24] Furthermore, studies conducted among Iranian children reported the highest hyperopia prevalence, 20.50%,[9] and the lowest at 4.0%.[41] The current study found highly significant regional differences in the prevalence of hyperopia among children, which is consistent with an earlier study[46] that found significant regional variation in refractive error prevalence from country to country, even within the same geographic region. The variation in hyperopia prevalence within the country and region could be due to genetic factors or the benchmarks for defining hyperopia or methods for measuring refractive error, some studies used dry refraction, and others used wet refraction. Thus, to eliminate the bias of design variation our study only included studies that defined hyperopia as spherical equivalent ≥2.00D; in addition, we calculated the pooled prevalence of hyperopia for studies that used cycloplegia and noncycloplegia separately.

Table 4: Childhood hyperopia prevalence by age group across Eastern Mediterranean Region studies (2000–2022)

Authors (years)	Country	Prevalence (95% CI)	Weight (%)
Children aged 5–10			
Yamamah *et al*., 2015[20]	Egypt	4.79 (3.00–6.00)	2.32
Alrasheed *et al*., 2016[21]	Sudan	1.18 (0.00–2.00)	7.33
Abdi Ahmed *et al*., 2020[22]	Somalia	4.04 (2.00–6.00)	1.37
Al Wadaani *et al*., 2013[23]	Saudi Arabia	2.07 (1.00–3.00)	4.85
Aldebasi, 2014[24]	Saudi Arabia	0.61 (0.00–1.00)	48.9
Jamali *et al*., 2009[29]	Iran	20.51 (18.00–23.00)	0.62
Hameed, 2016[30]	Pakistan	1.79 (1.00–2.00)	6.84
Fotouhi *et al*., 2007[31]	Iran	20.18 (18.00–22.00)	1.09
Alrahili *et al*., 2017[33]	Saudi Arabia	1.53 (1.00–2.00)	14.2
Alghamdi, 2020[34]	Saudi Arabia	9.11 (6.00–12.00)	0.57
Al-Rowaily 2010[38]	Saudi Arabia	2.12 (1.00–3.00)	7.17
Hashemi *et al*., 2018[41]	Iran	4.26 (2.00–6.00)	0.91
Kandi and Khan, 2021[43]	United Arab Emirates	2.18 (1.00–3.00)	3.88
All		5.72 (2.00–9.00)	100
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		99.59	
Children aged 11–17			
Yamamah *et al*., 2015[20]	Egypt	2.65 (2.00–4.00)	5.36
Alrasheed *et al*., 2016[21]	Sudan	2.43 (1.00–3.00)	4.68
Abdi Ahmed *et al*., 2020[22]	Somalia	1.77 (1.00–3.00)	5.17
Al Wadaani *et al*., 2013[23]	Saudi Arabia	0.80 (0.00–1.00)	17.6
Aldebasi, 2014[24]	Saudi Arabia	0.74 (0.00–1.00)	42.3
Hameed, 2016[30]	Pakistan	0.41 (0.00–1.00)	14.8
Fotouhi *et al*., 2007[31]	Iran	13.4 (12.00–15.00)	1.98
Bataineh and Khatatbeh, 2008[36]	Jordan	2.85 (2.00–4.00)	7.27
Hashemi *et al*., 2018[41]	Iran	4.03 (2.00–6.00)	0.86
All		3.23 (1.00–6.00)	100.00
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		99.16	

CI: Confidence interval

In general, the overall pooled prevalence of childhood hyperopia across EMR is slightly higher than reported among children globally.[47] The higher prevalence of hyperopia in EMR children compared with the other region may be related to the variation in the hereditary tendency to hyperopia development. EMR includes countries in Africa and Asia, in this review, most of the studies were from EMR countries in Asia, which may reflect the heterogeneity among the findings and slightly high childhood hyperopia prevalence. The high prevalence of childhood hyperopia may be related to the high proportion of people in this region who live in rural areas; this was mentioned as an associated factor for the development of hyperopia.

The prevalence of childhood hyperopia by gender was not significantly different between male and female children ($P > 0.05$), which was slightly high in females 4.34% compared to males 4.21%. Most of our reviewed studies revealed no statistically significant association between gender and hyperopia, this agreed with previously published meta-analysis on childhood hyperopia globally.[47] Castagno *et al*. reported that the contradictory results when measuring the association between sex and hyperopia may possibly be related to gender representativeness in the studies. Girls in some cultures and countries have more struggle in accessing schools, which might suggest selection bias in the prevalence of hyperopia.[47]

The younger children aged 5–10 years had a higher prevalence of hyperopia 5.72% compared to older children 11–17 years had a low at 3.23%, which was highly significant $P = 0.001$. From this finding, there is an inverse association between childhood hyperopia and age which agreed with previously published studies.[5,16,47] This decrease in childhood hyperopia prevalence is supposed to be related to an increase in the development of the eyeball and the end of emmetropization after 10 years of age. Rose *et al*.[48] reported that children aged 6 and 12 years who spent more time doing outdoor activities such as walking or doing outside sports and picnics were more hyperopic than those who spent less time practicing these activities.

The present study revealed that studies that used cycloplegic refraction reported a significantly higher prevalence of childhood hyperopia compared with studies that used noncycloplegic refraction, which was inconsistent with the earlier study.[47] Manny *et al*.[49] showed that cycloplegia refraction is the acceptable method of testing to diagnose

Table 5: Childhood hyperopia prevalence by refraction technique among school children in Eastern Mediterranean Region

Authors (years)	Country	Prevalence (95% CI)	Weight (%)
	Cycloplegic		
Chebil *et al*., 2016[50]	Tunisia	3.71 (3.00–4.00)	11.86
Yamamah *et al*., 2015[20]	Egypt	3.62 (3.00–4.00)	3.72
Alrasheed *et al*., 2016[21]	Sudan	1.85 (1.00–2.00)	5.80
Al Wadaani *et al*., 2013[23]	Saudi Arabia	1.35 (1.00–2.00)	9.44
Aldebasi, 2014[24]	Saudi Arabia	0.68 (0.00–1.00)	48.34
Yekta *et al*., 2010[25]	Iran	5.02 (4.00–6.00)	2.46
Rezvan *et al*., 2012[27]	Iran	5.42 (4.00–7.00)	1.90
Jamali *et al*., 2009[29]	Iran	20.51 (18.00–23.00)	0.35
Fotouhi *et al*., 2007[31]	Iran	16.6 (15.00–18.00)	1.58
Elmajri, 2017[32]	Libya	6.20 (5.00–8.00)	0.99
Gilal *et al*., 2022[35]	Pakistan	3.50 (2.00–5.00)	0.74
Bataineh and Khatatbeh, 2008[36]	Jordan	2.85 (2.00–4.00)	3.73
Fotouhi *et al*., 2011[39]	Iran	10.1 (9.00–11.00)	2.04
Hashemi *et al*., 2016[40]	Iran	6.21 (5.00–7.00)	4.38
Hashemi *et al*., 2018[41]	Iran	3.20 (2.00–6.00)	0.99
Hussam Uldeen Hatow *et al*., 2018[42]	Iraq	20.1 (17.00–23.00)	0.29
Kandi and Khan, 2021[43]	United Arab Emirates	2.18 (1.00–3.00)	2.15
Anera *et al*., 2009[45]	Morocco	18.3 (15.00–22.00)	0.23
All		7.35 (4.00–10.00)	100
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		93.52	
	Noncycloplegic		
Abbas *et al*., 2019[19]	Pakistan	8.91 (8.00–10.00)	4.32
Abdi Ahmed *et al*., 2020[22]	Somalia	2.66 (2.00–4.00)	6.56
Ullah *et al*., 2020[26]	Pakistan	2.05 (1.00–3.00)	16.02
Mohamed *et al*., 2017[28]	Sudan	1.09 (0.00–2.00)	10.70
Hameed, 2016[30]	Pakistan	1.28 (1.00–3.00)	18.37
Fotouhi *et al*., 2007[31]	Iran	2.10 (1.00–2.00)	12.78
Alrahili *et al*., 2017[33]	Saudi Arabia	1.53 (1.00–2.00)	17.68
Alghamdi, 2020[34]	Saudi Arabia	9.11 (6.00–12.00)	0.71
Ostadi Moghaddam *et al*., 2008[37]	Iran	8.40 (7.00–10.00)	3.91
Al-Rowaily, 2010[38]	Saudi Arabia	2.12 (1.00–3.00)	8.95
All		3.93 (2.00–6.00)	100.00
Heterogeneity between groups		P<0.001	
I^2 (inconsistency)		96.94	

CI: Confidence interval

ametropias, even though concerns remain as to its precision in children with darker irises.

This review had some limitations. These included variations in the study methods, such as some studies had a large sample size and others with small sample sizes may give over or underestimation of childhood hyperopia prevalence. Several studies were excluded from the review because they used different techniques or different age groups, which reduced the number of articles included. Furthermore, the study did not explore the various aspects affecting the epidemiology of childhood hyperopia in these inhabitants. Nevertheless, of these limitations, the current systematic review and meta-analysis estimated the pooled prevalence of childhood hyperopia in EMR and its difference with gender, age, and refraction method.

Conclusion

The prevalence of hyperopia among children in the EMR was high compared to other regions, particularly in younger children, and slightly more common among females. There is an inverse association between childhood hyperopia and age. More studies are required using standardized methods in different regions where there is a lack of information on childhood hyperopia prevalence. Early interventions of hyperopia are essential to be implemented in the EMR to protect future adults from the development of strabismus and amblyopia.

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Conflicts of interest

There are no conflicts of interest.

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